Youth Cannabis Use in Ontario During the COVID-19 Pandemic: A Longitudinal Cohort Study

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Preface

Approvals

Chapters 2 and 3 involved secondary data analysis of a dataset from a longitudinal cohort study, for which permission to transfer and use the data was obtained. The 'Cannabis Cohort Study' obtained ethics approval through the Research Ethics Board at the Centre for Addiction and Mental Health (CAMH) (REB#2021/001) and the University of Ottawa (H-11-21-7431). Jessica Berryhill (JB) received ethics approval from the University of Ottawa Research Ethics Board (H-07-24-10535) to conduct this secondary analysis (ethics certificate, Appendix A).

Author Contributions

The student (JB) was the primary author on both manuscripts included in this thesis, and they were co-authored by her supervisor, Dr. Tara Elton-Marshall (TEM), and her thesis advisory committee members, Dr. Ian Colman (IC) and Dr. Sameer Imtiaz (SI). JB was responsible for planning and executing the quantitative data analyses, interpreting findings and drafting each manuscript. At each step in the research process, TEM, IC, and SI provided guidance on the analytical approach and provided feedback on each chapter of this thesis.

Abstract

Objectives: This study aimed to examine changes in cannabis use, motivations for changing cannabis use patterns, and symptoms of cannabis use disorder (CUD) among Ontario youth (16-30) who used cannabis during the COVID-19 pandemic.

Methods: We analyzed the association between changes in cannabis use and motivations for increased use with changes in symptoms of CUD measured with the Cannabis Use Disorder Identification Test – Revised (CUDIT-R) using linear regression modelling.

Results: 58% of respondents reported increasing their cannabis use due to the COVID-19 pandemic, which was associated with increases in CUDIT-R scores at follow-up compared to baseline. This association of increased CUDIT-R scores was more pronounced among younger participants. Boredom and loneliness were identified as significant contributors to increases in cannabis use and symptoms of CUD.

Conclusion: Our findings underscore the need for targeted harm reduction programs to delay onset and discourage problematic cannabis use.

(144/150 words)

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List of Abbreviations

95% CI	95% Confidence interval
AIC	Akaike Information Criterion
ANOVA	Analysis of variance
BIC	Bayesian Information Criterion
CAMH	Centre for Addiction and Mental Health
CCHS	Canadian Community Health Survey
CCS	Canadian Cannabis survey
CRP	Cannabis-related problems
CUD	Cannabis use disorder
CUDIT-R	Cannabis use disorder identification test - revised
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, fifth edition
ICD-11	International Classification of Diseases 11th Revision
K6	Kessler Psychological Distress Scale (K6)
LRCUG	Lower-Risk Cannabis Use Guidelines
MET/CBT	Motivational enhancement therapy and cognitive behavioural therapy
MLA	Minimum legal age
OR	Odds Ratio
OSDUHS	Ontario Student Drug Use and Mental Health Survey
ROC	Receiving operating characteristic
REDCap	Research Electronic Data Capture
SDS	Severity of Dependence Scale
SEPH	School of Epidemiology and Public Health

SSS	Subjective Social Status
THC	Delta-9-tetrahydrocannabinol
VIF	Variance Inflation Factor
YLD	Years lived with disability

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1. Introduction

1.1 Cannabis Use in Canada

Cannabis is the most commonly used psychoactive substance globally, and the annual prevalence of cannabis use is 2.5% of the global population.[1] In Canada, the prevalence of cannabis use has been gradually rising over time from 5.6% in 1985 to 14.8% in 2017 and has long been most common among those aged 18 to 24 years.[2] The primary psychoactive component of cannabis is Δ-9 tetrahydrocannabinol (THC), responsible for the intoxicating nature of the substance.[1]

Recreational cannabis use in Canada became legalized on October 17, 2018, under the federal Cannabis Act, which established regulations to allow for legal production, possession, and consumption of cannabis.[3,4] The Cannabis Act was proposed as an effort to regulate profits from illegal cannabis sources, control cannabis production to address quality concerns and limit accessibility for youth.[3] Provinces and territories have control over the sale and distribution of cannabis within their jurisdictions, allowing for varying regulations across the country related to the minimum legal age (MLA) for use, specific allowable possession limits, and the location of cannabis retailers.[5] The majority of Canadian jurisdictions, including Ontario, set the MLA for recreational cannabis use at 19 years, with the only exceptions being Alberta and Quebec, which have MLAs of 18 and 21 years, respectively.[6]

The impact of the Cannabis Act on the prevalence of self-reported cannabis use was highlighted in the Canadian Cannabis Survey, which found that 25% of respondents in the 2019 post-legalization cycle reported cannabis use in the past year compared to 22% of respondents in the 2018 pre-legalization cycle.[7,8] It is important to note that increases in cannabis use, for instance, past-month cannabis use of young adults in Canada were noted before the Cannabis Act

took effect in October 2018.[9] Similar findings of significant increases in the reported prevalence of cannabis use post-legalization were reported in the National Cannabis Survey, where an increase in recent cannabis use rose from 14.0% in the first quarter of 2018 to 17.5% in the first quarter of 2019 among Canadians 15 years or older.[10] Cannabis use in the post-legalization era remained highest among individuals aged 18-24 years at 33.3%, which did not change from prior prevalence estimates seen in this age group in the year preceding legalization.[10]

Annual general population surveys administered to Canadians above the age of 15 have identified a trend of gradual increases in past-year cannabis use among all age groups from 22% in 2018 to 26% in 2024.[11] Interestingly, 41% of youth aged 16-19 years and 48% of respondents aged 20 to 24 years reported past-year cannabis use, with 47% of those respondents 16-24 years of age reporting daily or nearly daily use of cannabis.[11] Thus, a large proportion of Canadian youth are engaging in frequent cannabis use.

Adolescence and young adulthood represent a critical period of neurodevelopment when frequent cannabis use is associated with many adverse effects, including physiological changes in brain structure (e.g., loss of grey matter volume and white matter reductions) that are associated with impaired cognitive function.[12] Furthermore, cannabis use is associated with depression, anxiety, psychosis, suicidality, polysubstance use and cannabis use disorder (CUD) in youth.[13–17] Emerging evidence has identified numerous physical health effects of cannabis use, including cannabis-related traffic injuries, lung injury, respiratory distress, and cannabinoid hyperemesis syndrome.[18–20] In addition, previous literature has demonstrated that increased frequency of cannabis use, particularly daily cannabis use, is associated with a greater likelihood of experiencing cannabis-attributable harms.[19,21–23] As cannabis use rises in the youth population, so do emergency department visits and poor long-term health outcomes.[19,21–24] In Ontario, there

was a 4.8-fold increase in rates of cannabis-related emergency department visits by youth aged 10-24 years between 2003 and 2017.[24] Cannabis use, and particularly frequent cannabis use, among adolescents, therefore, represents a significant public health issue.

1.2 Cannabis Use Disorder

Cannabis use disorder (CUD) is a diagnostic term detailed in the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) and International Classification of Diseases, 11th Revision (ICD-11), which encompasses both cannabis abuse and cannabis dependence.[25–28] CUD is a culmination of cognitive, behavioural and physiological symptoms related to ongoing consumption of cannabis despite adverse effects of use on one's social, emotional and physical well-being.[29] According to DSM-5 diagnostic criteria, CUD is characterized by increases in quantity and frequency of cannabis use, continued use leading to neglect of social or occupational obligations, persistent cravings for cannabis, evidence of tolerance to the psychoactive properties of cannabis, symptoms of withdrawal and worsening of physical and mental health.[30,31] Evidence suggests an increased risk of CUD with increased frequency of cannabis use.[32] In North American adolescents, the current 12-month prevalence of CUD is 3%, with higher rates seen in older youth and males.[33] Heavy cannabis use during adolescent years has been associated with an increased risk of developing dependence, with an estimated 1 in 6 individuals initiating cannabis use during adolescence developing symptoms of cannabis dependence.[34] Sociodemographic and behavioural factors, including age, sex, and nicotine and alcohol use, have been associated with engagement in problematic cannabis use.[35] As of 2012, findings regarding the cannabis-attributable burden of disease in Canada identified CUD to be the primary contributor to the estimated 55,813 years of life lost due to disability

(YLD).[19] The implications of CUD for public health are significant in terms of costs to the healthcare system and reductions in health-related quality of life, particularly if dependence develops in youth and early adulthood.

The Cannabis Use Disorder Identification Test – Revised (CUDIT-R) is one assessment tool that is aligned with DSM-5 diagnostic standards, which can be used to screen for problematic cannabis use and possible CUD.[36–38] The CUDIT-R contains 8 items referencing frequency of cannabis use, ability to abstain from cannabis use, impacts of cannabis use on daily function, time spent obtaining/using cannabis, emergent issues with cognition, use of cannabis in circumstances where there is potential physical harm, and thoughts of limiting cannabis use during the last 6 months.[37] This tool demonstrated high discriminant validity across severity classifications of CUD detailed in the DSM-5, good internal consistency, and high sensitivity (0.93) and specificity (0.70).[27,37,38] Each item of the tool is scored between 0 and 4, corresponding to the increasing frequency of each of the symptoms of CUD, for a total possible score of 32, such that higher scores indicate a greater likelihood of problematic cannabis use or CUD.[39] Psychometric properties of the measure indicate that cutoff scores of ≥8 for hazardous cannabis use and ≥12 for possible CUD show optimal values of discriminant validity.[37,38,40] The items and corresponding response options included on the CUDIT-R can be found in **Appendix B**.

1.3 Youth Perceptions of Cannabis Use

The perceptions of cannabis use among youth can greatly shape their inclination to engage in problematic cannabis use, defined as patterns of use leading to adverse social and health-related consequences.[25] Qualitative research of young adults in Canada identified 'risk

denial' amongst participants as they believed cannabis is safer than prescription medications and has therapeutic benefits.[41,42] In a similar vein, undergraduate student participants did not think the physical and health risks of cannabis use would affect them personally, evidence of inaccurate perceived harmfulness of use.[41] Themes of reduction of stigma, normalization, and social acceptability of cannabis use emerge from discussions with youth who use cannabis across several Canadian research studies.[17,41–43] Individual perceptions of health risks of cannabis use directly influence cannabis-related decisions, including the frequency, quantity, and source of the cannabis they are consuming.[44] It is when the frequency and amount of cannabis consumption increase that youth are most at risk of developing CUD. Thus, discourses surrounding the normalization, social acceptability, and potential harms of cannabis use influence youth decisions about its use.

1.4 Cannabis Use Disorder in Youth

The prevalence of youth cannabis use and dependence has risen in recent years, particularly since cannabis legalization.[17,45] A retrospective study of individuals over 18 years old presenting to a Quebec emergency room for psychiatric consultation revealed a statistically significant increase in the odds of CUD post-legalization compared to pre-legalization (OR: 2.27; 95% CI: 1.17, 4.40).[46] In 2020, data from the Canadian Community Health Survey (CCHS) found that 4.7% of respondents met the criteria for impaired control over their cannabis use based on the Severity of Dependence Scale (SDS), which is a precursor to CUD.[47] In this study, youth aged 18-24 years had higher odds of meeting the threshold for impaired control over their substance use compared to individuals aged 15-17 and those aged ≥25 years.[47] In 2023, the Centre for Addiction and Mental Health's (CAMH) Monitor found that 61.4% of those 18-29

years of age who use cannabis in Ontario met the criteria for moderate to high risk of cannabis related harms.[48] Moreover, the 2023 Ontario Student Drug Use and Health Survey (OSDUHS) revealed that 16.9% of youth in grades 9 to 12 who used cannabis within the past year reported symptoms of cannabis dependence, including immense difficulty refraining from use and worries about the implications of their use.[49] Overall, there is growing concern about cannabis use in the youth population, as a substantial proportion of those using the substance are exhibiting symptoms of dependence.

1.5 Impacts of the COVID-19 pandemic on cannabis use in Canada

The public health emergency measures implemented in response to the rapidly evolving COVID-19 pandemic profoundly impacted patterns of cannabis consumption. Across Canada, enforced lockdown measures led to the closure of non-essential businesses, educational institutions, and recreational activities, as well as the suspension of non-urgent health services and elective procedures. In Ontario, the provincial government initially declared recreational cannabis "non-essential" but quickly reversed its decision and allowed delivery and curbside pick-up from brick-and-mortar retailers.[50] Social distancing and mandatory quarantine following travel or infection with the virus resulted in increased feelings of isolation, particularly among the most vulnerable populations, including those dealing with mental health concerns, as well as youth and young adults.[51] Retail cannabis sales increased early on in the pandemic, beginning in March 2020, compared to pre-pandemic levels in all Canadian jurisdictions, excluding Prince Edward Island.[39] Corresponding with recreational cannabis legalization, there was a rapid expansion of the retail cannabis market before and during the pandemic, with 3305 stores operating across Canada as of 2022, which has increased access to cannabis.[52]

Several cross-sectional surveys in Canada found self-reported cannabis consumption and frequency of use increased during the COVID-19 pandemic, particularly among young adults aged 18-29 years.[12,18,21,53] Additionally, one cross-sectional analysis found that the overall prevalence of cannabis use remained stable, while there were notable increases in use identified among those who engage in cannabis use.[22,54] During the early phase of the pandemic, a repeated cross-sectional study of Canadians in May and June of 2020 found that those 18-29 years of age had 2.61 times the odds of increasing their cannabis use compared to those above the age of 50 years. [22] Additionally, a cross-sectional survey conducted between August 2020 and March 2021 identified that 73% of youth and young adults (16-25 years of age) who were using cannabis daily reported increasing their consumption during the pandemic.[55] The intermittent lockdown measures restricted youth from attending educational institutions, engaging in employment, participating in extracurricular activities, and socializing during the height of the pandemic. The flux of restrictions on the lifestyle of youth had downstream effects on their substance use patterns and risk for CUD, as evidenced in the aforementioned studies.

1.6 Motives for Cannabis Use among Youth

The motives driving youth to initiate and maintain cannabis use over their life-course are varied due to the heterogeneity in their social, economic, cultural, and physical environments. The interconnectedness of these environments, along with personal experiences, shapes one's beliefs about the benefits and harms of substance use. Broadly, the reasons youth use cannabis are widely classed as either positive or negative reinforcers.[56] Positive reinforcers are motives viewed to provide enhancements to the life and experience of the cannabis user. These positive reinforcement motives include, but are not limited to, enjoyment, relaxation, euphoric sensation,

expansion/altered perception, and increased sociability when using cannabis.[29,56] A systematic review examining the connection between motives for use and substance use behaviours found that each of the motives mentioned above, aside from conformity, was positively associated with a youth's intention to use cannabis and increased frequency of use.[56] It must be noted that findings were inconclusive regarding the effect of each motive on the prevalence of cannabis-related harms.[56] Negative reinforcers are motives related to cannabis use as a means to alleviate unpleasant experiences and/or emotions. These negative reinforcement motives for use include, but are not limited to, coping with negative affect (i.e., boredom, anger, anxiety), conformity, and managing symptoms of health conditions (i.e., reducing depression or pain).[29,56,57] Coping and boredom were independently associated with increased frequency of cannabis use in youth; however, conformity was primarily noted as a motive for those who use cannabis occasionally, with no conclusive association with patterns of use.[56] A systematic review of the literature found that coping remains the most consistently reported motive for cannabis use and is consistently associated with increased risk of adverse consequences from cannabis use, based on the Marijuana Problems Scale, which identifies how one's use has impacted relationships, productivity, and physical health, as well as symptoms of CUD.[56] A longitudinal analysis of youth who use cannabis found that those who reported using the substance for health purposes, such as managing pain, had accelerated increases in rates of cannabis use over time.[57] Ultimately, many intersecting motives for cannabis use have been identified in the youth population, which provides greater insight into the trajectory of use from initiation to, in some cases, symptoms of CUD.

The COVID-19 pandemic exacerbated stress at the individual and familial level with fluctuating access to in-person education, social gatherings, and employment opportunities,

which took a toll on the mental health of youth. The toll of social isolation, worrying about family well-being, and financial concerns posed a significant threat to youth mental health. Predominant reasons reported in the literature for changes in cannabis consumption during the pandemic include loneliness, boredom, stress, feelings of depression, ease of access and lack of structure in daily routines.[51,58–60] For instance, a longitudinal analysis of the mental health symptoms in Canadian adolescents identified that financial worry and low family and friend support were significantly associated with increases in anxiety during the pandemic compared to pre-pandemic responses.[58] Coping with mental health symptoms, specifically depression, anxiety, stress, and loneliness, contributed to increases in cannabis use among youth as reported in a systematic review of cannabis use in American and Canadian youth during the pandemic.[61] In a sample of young adults in the United States, there was an increase in boredom being noted as the primary motive for cannabis use during the pandemic.[59] Interestingly, youth adherence to self-isolation protocols in Canada was a significant predictor of increased cannabis use, wherein those self-isolating used 20% more cannabis compared to those not in self-isolation.[51] Further, respondents who consistently reported using cannabis to cope with depression used 31% more cannabis than those not reporting this motive.[51] Key determinants of cannabis use during the pandemic mirrored the positive and negative reinforcers of use in the pre-pandemic era, with coping motives emerging as the leading factor contributing to increased cannabis use.

1.7 Factors influencing patterns of cannabis use

The vast literature on the topic of cannabis and CUD has identified several sociodemographic and behavioural characteristics associated with one's likelihood of consuming cannabis, the frequency and quantity consumed, and susceptibility to cannabis-attributable

harms.[62] These factors include, but are not limited to age, gender identity, ethno-racial background, rurality of residence, and mental health status.[45,60,62–65]

Age is an important factor to consider as younger age groups (20-24 years) are reported to have the highest prevalence of cannabis use, and adolescents 12-18 years of age are at the highest risk of cannabis dependence.[11,66] Earlier initiation of cannabis use, particularly before 16 years of age, is associated with accelerated progression to cannabis dependence and increased risk of CUD.[67,68]

Gender is associated with cannabis use and dependence, with men/boys being more likely to use and become dependent on cannabis.[43,69] Gender identity, and the interpersonal connections where the patterns of interaction, power dynamics, and relational expectations are constructed and reinforced through social processes and cultural gender norms have been shown to influence initiation and patterns of cannabis use.[45] There is a unique phenomenon pertaining to the trajectory of cannabis use from initiation to CUD among individuals identifying as women/girls.[70] Women and girls are significantly more likely to accelerate their transition from initiation of cannabis use to an increase in use and incidence of CUD.[70,71]

Ethno-racial background is associated with differential cannabis use among adolescents.[72] A cross-sectional analysis of Ontario youth in grades 7-12 determined that individuals identifying as mixed-race had higher odds of using cannabis than their White peers.[72] Ethno-racial background informs many of the norms and attitudes youth may hold regarding the acceptability and their openness to use substances, including cannabis.[73]

Rurality of one's dwelling has been associated with the likelihood of an individual using cannabis.[64] A Canadian study used data from 755 individuals enrolled in a randomized control trial for a cannabis intervention to collect data on the association between remote living and

cannabis use behaviours.[64] Results of this study indicate rural living is associated with less risky cannabis use and fewer self-reported cannabis-attributable harms. Measures of cannabis risk were based on responses to the Marijuana Problem Scale, which captured whether participants reported consequences of cannabis use (social relationships, self-esteem, work, physical and/or mental health) to be a serious problem in their lives.[64] In essence, rurality is associated with reduced risk of experiencing psychosocial, physical and psychological health impairments related to CUD.[64]

Comorbid mental health disorders and psychological distress are important considerations that have been associated with frequent cannabis use and, consequently, cannabis dependence.[65,74] Data derived from a nationally representative sample of Canadians detected an increase in the odds of drug use/dependence among individuals 15 to 29 years of age and those reporting major depressive episodes.[65] Similarly, a study in the United States using data from the National Survey on Drug Use and Health in 2020 found significantly heightened risk of CUD among those under 35 years of age who displayed mild, moderate or severe psychological distress as assessed by the Kessler-6 screening tool (K6).[74] Ultimately, addressing youth cannabis use is a complex public health issue which requires proper attention to risk factors for cannabis dependence, motives for use, accessibility to the substance, and long-term health consequences.

1.8 Present state of knowledge on cannabis use and dependence among Canadian youth following COVID-19

Several systematic and scoping reviews have been published on the topic of cannabis use during the COVID-19 pandemic in Canada that serve as the knowledge base supporting the

current research objectives. Firstly, a scoping review conducted by Bonnet et al. [75] explored pandemic-related changes in cannabis use and/or dependence in youth and adults globally. The review included 19 studies, with six from Canada, finding mixed results for both changes in cannabis use and dependence as a result of the COVID-19 pandemic.[60,75] Furthermore, a second systematic review also conducted in 2022 found 15 articles of interest, four from Canada, related to the impact of COVID-19 on cannabis use patterns as well as mental health symptomatology influencing substance use behaviours.[61] Several of the included studies noted an increase in cannabis use, primarily amongst individuals with existing cannabis use, and symptoms of poor mental health were reported as the leading cause of increased cannabis use.[61] Mehra et al.[76] conducted a scoping review exploring changes in cannabis use and sociodemographic characteristics associated with changes in use after the pandemic, as reported in the literature published between January 2020 and May 2022. Of the research articles identified, 48% reported increased cannabis use, 36% found no change, and 16% noted a decrease in cannabis use since the pandemic. However, it is worth noting that the majority of these studies were conducted internationally, with only 22% of the studies originating from Canada.[76] Thus, the results do not fully reflect the situation in Canada during the pandemic.[76] There are jurisdictional differences in recreational cannabis legalization and pandemic-related restrictions, making it crucial to use Canadian data to provide insights on the topic, which recognizes the unique circumstances surrounding cannabis accessibility and availability to this population. Finally, a scoping review examined research conducted in Canada on patterns of cannabis consumption during the pandemic (between March 2020 and September 2021).[54] The primary theme that emerged from this scoping review was that cannabis consumption during the pandemic differed based on reason for use, age, gender and method of consumption.[54] Findings from individual studies

examining changes in cannabis use in Canada during the pandemic will be discussed in sections 1.8.1 and 1.8.2.

1.8.1 Cross-Sectional Studies

A summary of referenced literature with cross-sectional study designs on the topic of changes in cannabis use in response to the COVID-19 pandemic among Canadian youth and young adults is available in **Table 1**. All studies found an upward trend in cannabis use during the pandemic, particularly among those with existing cannabis use and young adults.[21,22,77–82] There were notable increases in cannabis use during the pandemic in Canada in the majority of studies identified, ranging from 34% to 56%.[22,55,83] The average number of days a sample of high school students used cannabis significantly increased after the onset of the pandemic compared to pre-pandemic levels.[79] Additionally, among a sample of 16 to 25-year-olds in Canada, 73% of those who use cannabis daily increased the quantity they consumed because of COVID-19 stressors.[55] These studies indicate heightened cannabis usage during the pandemic; however, they do not demonstrate the effect these changes had on cannabis-related harms, including symptomatology of CUD.

Table 1. Summary of key findings from cross-sectional studies on youth cannabis use in Canada during the pandemic.

Author(s) & Date	Sample	Time Frame	Main Finding(s)
Chaiton et al., 2022 [55]	16–25-year-olds residing in Canada reporting use of cannabis, cigarettes, e-cigarettes, or alcohol within the past year (n= 6,721; 21% male)	August 2020 – March 2021	• 73% of those engaging in daily cannabis reported increasing their use due to the COVID-19 pandemic. • Net increase in cannabis use overall was 47% in response to the pandemic.

Dumas et al., 2020 [79]	Canadian high school students (aged 14-18 years) (n=1,054; mean age = 17 years; 22% male)	April 4th -13th, 2020	• Average number of cannabis using days significantly higher 3 weeks post onset of the COVID-19 pandemic compared to 3 weeks prior to COVID-19 crisis ($F(1, 1,029) = 8.04$, $p = .01$).
Imtiaz et al., 2021 [22]	Canadian adults (n=3,012; 22% aged 18-29; 53% male)	Repeated cross-sectional (3 waves); May 8 – June 23, 2020	• Approximately half of respondents with existing cannabis use reported increasing their usage during the pandemic at each survey wave (Wave 1: 52%; Wave 2: 56%; Wave 3: 48%). • Individuals between 18 and 29 years of age were at higher odds of increasing their cannabis use compared to those ³ 50 years (OR: 2.53 95% CI: 1.39, 4.59).
Imtiaz et al., 2022 [21]	Canadian adults (n= 6,021; majority aged 30-39 at each wave)	Repeated cross-sectional (6 waves); May 8 – December 1, 2020	• Daily cannabis use remained stable across survey waves (5.34% – 6.10%; p = 0.30). • Odds of daily cannabis use was higher in the 18-29 age group compared to those ³ 50 years (OR: 2.36 95% CI: 1.56, 3.57).
Leatherdale et al., 2021 [80]	High school students in grades 7-12 from 43 schools in Ontario and Quebec (n=7496)	May 1-July 6, 2020	• 27.3% of participants reporting past-year cannabis use indicated their increased their usage because of the pandemic while 23.2% reported decreasing their use. • 27.4% of youth who use cannabis in this sample reported using the substance to cope with changes related to the pandemic.
Prowse et al., 2021 [77]	Undergraduate students (aged 18-29 years) from Carleton University, Ottawa, Ontario (n=366; mean age = 21 years; 28.1% male)	May – August, 2020	• 17.5% of the sample reported at least moderate cannabis usage as a means to cope with the stress of the pandemic and there was no significant difference by gender. • Significant positive correlation between using cannabis to cope with COVID-19 and reporting negative impacts of the pandemic on their mental health ($r_s = 0.16$, $p<0.01$).

Rotermann, 2021 [10]	Canadian adults ³15 years of age (n=16,467)	Repeated cross-sectional Wave 1: February-March, 2018 Wave 2: February-March, 2019 Wave 3: November-December, 2020	• Cannabis use in the past three months increased in prevalence from 14% in 2018 to 20% in 2020. • There was a higher prevalence of cannabis use among individuals 18-24 years of age. • Rates of female cannabis consumption rose to meet those of males in 2020. • There was an increase in daily or almost daily cannabis use from 5.4% in 2018 to 7.9% in 2020. • Across Canada there was an 8-fold increase in the number of legal cannabis retailers from 2018 to 2020.
Statistics Canada, 2021 [81]	Canadians ³15 years of age (n= 3,94)	January 25 – 31, 2021	• Overall, 34% of those already engaging in cannabis use reported increasing their usage compared to pre-pandemic levels. • 43% of individuals 18 to 29 years of age who already engaged in cannabis use increased their usage during the pandemic.
Varin et al., 2021 [82]	Canadian adults (n=12,344; 49% male)	September 11 – December 4, 2020	• Self-reported changes in cannabis use during COVID-19: 5.4% increased, 1.8% decreased, 19.5% had no change, and 73.3% had never used cannabis. • The highest percentage of increased cannabis use was observed among those 18-24 years (12.1% of sample in this age group including those who have never used cannabis).
Vedelago et al., 2022 [78]	Canadians reporting cannabis use within the preceding 3 months (n=137; mean age=31 years; 55% male)	April 30-May 4th, 2020	• Coping motives for cannabis use during the pandemic mediated the association between pre-COVID frequency of cannabis use and cannabis-related harms after the onset of the pandemic. • Frequency of cannabis use in the COVID-19 era had a significant positive correlated with subsequent cannabis-related harms (r = 0.347, p<0.01).

Abbreviations: OR, odds ratio; CI, confidence interval; r_s, Spearman correlation coefficient.

1.1.1 Longitudinal Studies

A summary of referenced literature with longitudinal study designs on the topic of changes in cannabis use in response to the COVID-19 pandemic, specifically among Canadian youth and young adults, is available in **Table 2**.[51,80,84,85] Longitudinal study designs can provide valuable information on the temporality of increased cannabis use and adverse health outcomes, including CUD. One study conducted in Canada examined cannabis use longitudinally before and immediately following the onset of the COVID-19 pandemic to establish the role of self-isolation as a driver of increased cannabis use during the pandemic.[51] This study found that individuals adhering to self-isolation measures enacted during the pandemic were using approximately 20% more cannabis than those not self-isolating.[51] Additionally, a study was conducted that used three waves of national survey data from two years before and the year of COVID-19 onset from youth in grades 9-12 to examine the direction of change in youth cannabis use over this period.[80] This study found increased daily, weekly and monthly use of cannabis between 2018 and 2020.[80] Finally, Dumas et al.[85] conducted a study using four survey waves completed by Canadian adolescents, finding that the odds of an adolescent using cannabis were 9.4 times higher in June 2021 compared to April 2020. Much of the existing literature has focused on the initial effects of the COVID-19 pandemic on substance use patterns, and there is a notable lack of research examining these changes at later stages of the pandemic in Canada. Overall, these studies looked at identifying increases in cannabis use, specifically during the first year of the COVID-19 pandemic, but do not examine whether these observed changes are significantly associated with cannabis-related harms, including CUD.[51,80,84,85]

Table 2. Summary of key findings from longitudinal studies on youth cannabis use in Canada during the pandemic.

Author(s) & Date	Sample	Time Frame	Main Finding(s)
Bartel et al., 2020 [51]	Canadian emerging adults aged 19 to 25 years with use of both alcohol and cannabis pre-pandemic (n=70; mean age=23 years; 34% male)	Pre-pandemic: ~December 2019 Pandemic: March 23-June 5, 2020	• Self-isolation and coping with negative affect were significant predictors of changes in cannabis use during the pandemic. • Participants who adhered to self-isolation used 20% more cannabis during the pandemic than those who did not adhere to this public health measure.
Dumas et al., 2022 [85]	Canadian adolescents aged 14-18 years (n=1,068; mean age=17 years; 21% male)	Time 1: April 2020 Time 2: August 2020 Time 3: January 2021 Time 4: June 2021	• After the lifting of the first stay-at-home orders, there was an increase in an adolescent's likelihood of using cannabis that remained throughout subsequent survey waves. • The odds of an adolescent using cannabis was 9.64 ($p < 0.001$) times higher at time 4 compared to time 1.
Leatherdale et al., 2021 [80]	High school students from 43 schools in Ontario and Quebec (n=1937 for longitudinal component; mean age= 14 years at baseline; 47% male)	Time 1: 2018 Time 2: 2019 Time 3: May 1-July 6, 2020	• There was an increase in frequency of cannabis use (monthly, weekly, and daily) between each survey wave with the highest rates of use reported in the 2020 cycle. • Larger reduction in expected monthly and weekly cannabis use in older respondents compared to their younger counterparts. • While there were reduced escalation of daily cannabis use during the pandemic among males, there was no reduction in expected escalation of daily use in females.
Sylvestre et al., 2022 [84]	Former Quebec high school students with ages	Cycle 21: 2007-2008	• Prevalence of cannabis use in the sample rose from 17.5%

	20.4 to 33.6 years across 4 survey cycles (n=704; mean age=33.6 years at cycle 24; 42% male)	Cycle 22: 2010-2012 Cycle 23: 2017-2020 Cycle 24: December, 2020 – June 2021)	pre-pandemic to 23.1% during the pandemic. • Incidence of cannabis initiation or increased cannabis usage was higher during the pandemic 22.4% compared to results from pre-pandemic survey waves.

1.9 Rationale

Much data surrounding cannabis use is derived from broader national health surveys that capture the prevalence of substance use in a representative sample of the population, in which those who use cannabis represent only a portion of the entire sample. This often results in sample sizes that do not have enough power to examine factors associated with cannabis dependence. Many surveys of individuals who use cannabis classify recent cannabis use as use within the past year; however, inclusion of only those who have used cannabis in the past three months would provide greater insight into trends of use among those most at risk of cannabis attributable harms. In the post-cannabis legalization landscape, provincial jurisdiction over the cannabis regulations, including the minimum legal age and the commercial cannabis market, inevitably impacts the availability and use of cannabis products in different regions across Canada. As such, provincial-level data would provide a more in-depth description of youth cannabis use and their CUD risk, recognizing the province-specific nuances in cannabis regulation frameworks, demographics or reasons for changing cannabis use that may be overlooked in national data.

While previous research has identified increased cannabis consumption during the early stages of the pandemic, there remains a lack of studies examining whether these changes are having an impact on the likelihood of cannabis dependence in youth who use cannabis in the

wake of the COVID-19 pandemic. The cross-sectional and longitudinal studies currently found in the literature focus on identifying whether there was, in fact, any increase in cannabis use across the pandemic, but do not examine whether the reported change is associated with a rise in signs of CUD. Despite recognition in the literature of increased frequency of cannabis use during the COVID-19 pandemic, particularly among youth populations, the long-term impacts of these changes in substance use behaviour on cannabis dependence have yet to be examined as a longitudinal outcome. Although pandemic restrictions have come to an end, understanding the ramifications of increased cannabis use on adolescent health persists, and this necessitates ongoing investigation into the long-term impact on the mental and overall well-being of adolescents. Understanding pandemic-induced changes in cannabis use patterns among adolescents can provide valuable foresight for future trends in usage and allow us to be equipped with the knowledge required to develop proactive public health interventions.

Additionally, demographic and socioeconomic risk factors associated with cannabis dependence during a time of public health crisis have not been investigated explicitly in youth and young adults reporting recent cannabis use. Examining changes in cannabis dependence scores over time among a cohort of youth who use cannabis is essential for informing public health officials. Pandemic-related changes may interact with sociodemographic risk factors to result in differential changes in cannabis use. A significant body of literature exists regarding intersectional identities (e.g. gender, ethno-racial background) playing a role in determining one's likelihood to use cannabis and do so problematically.[69] Thus, the identification of sociodemographic factors associated with increased cannabis dependence can help public health officials target youth at risk of problematic cannabis use and provide ample substance reduction and safe substance use resources to youth during times of increased individual and societal

stress. Understanding how cannabis dependence may change during a public health crisis, such as COVID-19, will provide insight into predicted population-level changes in substance use behaviours and dependence during future public emergencies that impact substance use among youth. Thus, from a public health perspective, examining youth scores on a cannabis misuse and dependence screening tool can address gaps in the literature and support age-relevant health education campaigns to prevent increased personnel and financial strain on the healthcare system from cannabis-related medical encounters.

This study aims to understand how the increase in cannabis use attributed to the pandemic affected cannabis dependence in 2022 and 2023 among youth and young adults who use cannabis in Ontario. The study uses data from a longitudinal survey on changes in cannabis use during the pandemic among youth in Ontario specifically. Regression modelling will be used to examine the association between symptoms of CUD and changes in cannabis use, as well as reasons for increased use. The analyses will control for socio-demographic factors and CUDIT-R score at baseline to focus on the direction and magnitude of change in scores between the assessment time points. These analyses will be supplemented by a latent class analysis—a probabilistic modelling approach used to identify subgroups based on categorical indicators. In this context, the indicators will be the reasons participants reported increasing their cannabis use.[86] The goal is to determine whether specific subgroups are associated with greater symptoms of CUD at follow-up. These findings will be informative not only to describe changes in cannabis dependence among youth during the COVID-19 pandemic but also to strengthen the literature on youth changes in cannabis use behaviour during future public health crises. Thus, the use of data from an online questionnaire designed with a cannabis use focus and a sample of only individuals with recent cannabis use provides greater insight into potential

changes over time in cannabis consumption and CUD screening score among individuals currently engaging in cannabis use.

1.10 Research Objectives

(1) To examine whether increased cannabis use during the COVID-19 pandemic is associated with changes in symptoms of CUD in a youth population.

(2) To identify whether the motivating factors for increased cannabis use are associated with changes in symptoms of CUD.

1.11 Structure of Thesis

This thesis will be presented in a thesis-by-manuscript format in accordance with guidelines provided by the School of Epidemiology and Public Health at the University of Ottawa. A preface will be included for each manuscript to indicate its relevance to the context and objectives of the overall thesis.

Chapter 1 provided an in-depth overview of the existing literature on the topic, as well as the rationale and objectives for the thesis.

Chapter 2 is one of two component articles that describe the longitudinal quantitative analysis of changes in cannabis use as it relates to symptoms of CUD. This manuscript is entitled "Changes in Symptoms of Cannabis Use Disorder of Ontario Youth across the COVID-19 Pandemic: A Longitudinal Cohort Study" and was authored by Jessica Berryhill, Dr. Ian Colman, Dr. Sameer Imtiaz and Dr. Tara Elton-Marshall. This manuscript is prepared for submission to the Journal of Drug and Alcohol Dependence.

Chapter 3 reports on the findings from the prospective longitudinal analysis of youth who use cannabis in Ontario, wherein we examined the associations between motives for increasing cannabis use during the pandemic and subsequent changes in symptoms of CUD. This manuscript is entitled "Motivations for Youth Cannabis Use in Ontario during the COVID-19 Pandemic: A Longitudinal Cohort Study" and is authored by Jessica Berryhill, Dr. Ian Colman, Dr. Sameer Imtiaz and Dr. Tara Elton-Marshall.

Chapter 4 presents an overall discussion that interprets the study findings and their implications for public health policy and future research.

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2. Changes in Symptoms of Cannabis Use Disorder Levels of Ontario Youth across the COVID-19 Pandemic: A Longitudinal Cohort Study

Preface

Objective: To examine whether increased cannabis use during the COVID-19 pandemic is associated with changes in symptoms of CUD in a youth population.

Author Contributions: Jessica Berryhill conducted quality assurances on the baseline and follow-up datasets, developed the analytical approach, performed all analyses, and wrote the draft manuscript. Dr. Tara Elton-Marshall provided methodological expertise on the analytic approach and the written manuscript. Dr. Ian Colman and Dr. Sameer Imtiaz revised the analytic approach, provided guidance on conducting the multiple imputation and regression models, and reviewed the manuscript.

Publication: This manuscript is prepared for submission to the Drug and Alcohol Dependence journal.

Ethics: The University of Ottawa Research Ethics Board approved this secondary analysis (certificate, **Appendix A**).

Changes in Cannabis Symptoms of Cannabis Use Disorder of Ontario Youth across the COVID-19 Pandemic: A Longitudinal Cohort Study

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Abstract

Background: Cannabis use increased among many youth during the COVID-19 pandemic. However, there is a lack of research examining whether there were lasting changes in cannabis use, and in particular, problematic cannabis use, after the pandemic. This is particularly important to examine among young adults because problematic cannabis use is associated with a greater likelihood of impaired neurodevelopment and adverse health outcomes.

Methods: The study was a longitudinal cohort survey of Canadian youth (n=1579; 55% female; mean age 22 years) aged 16 to 30 residing in Ontario who reported cannabis use in the past three months. Respondents completed online questionnaires regarding their cannabis use in 2022 and again in 2023. Linear regression examined the association between reporting increased cannabis use during the pandemic and changes in symptoms of cannabis use disorder (CUD) (measured by the cannabis use disorder identification test – revised (CUDIT-R)). Models were adjusted for sociodemographic factors and psychological distress.

Results: Linear regression indicated that increased cannabis use in response to the COVID-19 pandemic was significantly associated with increased CUDIT-R scores across survey waves (β: 1.49; 95% CI: 0.99, 2.00). The association between increased cannabis use and changes in symptoms of CUD was stronger for younger participants (p=0.04).

Conclusion: The COVID-19 pandemic was associated with increasing symptoms of CUD, particularly among youth, even three years after it was initially declared. This study highlights the importance of addressing the ongoing impacts of the COVID-19 pandemic and developing strategies to prevent hazardous substance use in future health crises.

(247/250 words)

Keywords: Cannabis use; Cannabis use disorder; COVID-19; Youth; Ontario

Highlights

- The COVID-19 pandemic impacted the cannabis use behaviours of youth in Ontario
- The majority of youth reported increasing their cannabis use in response to COVID-19
- Increased cannabis use during COVID-19 was associated with elevated symptoms of CUD
- Younger individuals who increased cannabis use showed a rise in problematic use
- Findings suggest youth may experience more symptoms of CUD post-pandemic

2.1 Introduction

2.1.1 Cannabis Use in Canada

Recreational cannabis use was legalized in Canada on October 17, 2018, under the federal Cannabis Act, which established regulations to allow for the legal production, possession, and consumption of cannabis.[1,2] Cannabis is the most widely used drug in Canada, with 26% of the population reporting recreational cannabis use within the past year as of 2024.[3] Use is highest among Canadian youth and young adults, with a prevalence of use within the past year of 41% for those aged 16-19 years and 48% for those aged 20-24 years.[3] Youth and young adults in these age ranges also have a higher propensity to increase their cannabis use and/or use cannabis on a daily or near-daily basis.[4–6]

Youth represents a period of critical neurodevelopment during which individuals are more vulnerable to the adverse effects of increased cannabis use and establish substance use habits that follow them into adulthood.[7] Cannabis use during youth is associated with adverse mental and physical health outcomes, including psychosis, deficits in memory and motor function, risk of motor vehicle accidents, polysubstance use, and substance dependence.[8,9] Increased frequency of cannabis use, particularly daily cannabis use, is associated with a greater likelihood of experiencing cannabis-attributable harms.[8,10] Cannabis use disorder (CUD) is a diagnostic term detailed in the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) and International Classification of Diseases, 11th Revision (ICD-11) that refers to both cannabis abuse and cannabis dependence.[11,12] Cannabis abuse and dependence represent clinically significant impairments of psychological, social, and physical function.[11] Findings regarding the cannabis-attributable burden of disease in Canada as of 2012 identified CUD to be the single most significant contributor to the estimated 55,813 cannabis-attributable years of life

lost due to disability (YLDs).[13] Heavy cannabis use during adolescent years has been associated with an increased risk of developing dependence.[6] The Government of Canada estimates that 1 in 6 individuals who use cannabis in Canada and initiated use during adolescence will develop CUD.[14]

2.1.2 COVID-19 Impacts on Youth Cannabis Use

Cannabis is often used as a coping mechanism among youth, particularly in coping with negative affect, which is widely cited as the primary motivation for substance use.[15,16] With coping with negative emotions driving youth toward cannabis use, the coronavirus pandemic (COVID-19) posed a significant threat of problematic substance use due to emotional, financial, social and physical stressors. The public health emergency measures implemented in response to the rapidly evolving COVID-19 pandemic profoundly impacted patterns of cannabis consumption.[17] Across the globe, enforced lockdown measures resulted in the closure of non-essential businesses, educational institutions, and recreational activities starting in March 2020.[18]

Several cross-sectional and longitudinal surveys in Canada found self-reported cannabis consumption and frequency of use increased during the COVID-19 pandemic, particularly among young adults 18-29 years of age.[10,19–22] However, there were notable increases in cannabis use identified in those with prior cannabis use.[23] Predominant reasons reported in the literature for changes in cannabis consumption during the pandemic include loneliness, boredom, stress, feelings of depression, ease of access and lack of schedule.[17,24–26] A study conducted in Canada revealed that individuals adhering to self-isolation measures during the COVID-19 pandemic increased their cannabis use by approximately 20% compared to those who were not self-isolating.[24]

2.1.3 Rationale

Cannabis consumption and frequency of use increased during the COVID-19 pandemic in Canada, particularly among young adults; however, there has been a lack of research examining whether there were clinically meaningful and sustained increases in the prevalence of CUD.[23,27] Given the correlation between the frequency of cannabis use and the symptomatology of CUD, it is critically important from a public health perspective to assess whether there have been long-term increases in CUD following the pandemic.[28] The objective of the current study was to examine whether increased cannabis use during the COVID-19 pandemic was associated with subsequent increases in CUD symptoms in a youth population.

2.2 Methods

2.2.1 Data Source

A longitudinal rolling cohort study design was operationalized using data from two waves of an online survey administered to a sample of Ontario youth and young adults, defined herein as individuals aged 16 to 30 years, who use cannabis. The study aimed to capture patterns of cannabis use, methods of cannabis use, cannabis-impaired driving, risk perception of cannabis use, exposure to existing cannabis-related public health education campaigns and demographic information. The online cannabis cohort survey was designed and administered by a team at the Centre for Addiction and Mental Health (CAMH), the University of Toronto and the University of Ottawa. The survey was conducted using the Research Electronic Data Capture (REDCap) software.[29,30] Respondents were recruited through targeted ads on Instagram and Facebook, from an existing cohort study on vaping in Ontario at the University of Toronto, and via digital flyers

distributed through CAMH's Cannabis Knowledge Exchange Hub and Evidence Exchange Network.

Wave 1 of this survey was conducted between January and August of 2022, and Wave 2 was conducted between January and August of 2023. The Wave 2 survey was administered approximately a year after the completion of the Wave 1 survey. Participants were deemed eligible for the study if, at baseline (Wave 1), they were between the ages of 16 and 30 years, resided in Ontario, and reported recent cannabis use, defined herein as use within the preceding 3 months. Of those eligible, there was ≤5% missingness for each variable of interest. Thus, a complete case approach was operationalized, and the merged database contained data from 1,579 respondents at both survey waves. **Appendix C** provides a comprehensive flow diagram illustrating the data preparation process.

2.2.2 Measures

2.2.2.1 Outcome

The change in symptoms of CUD score between the baseline (Wave 1) and follow-up (Wave 2) survey was derived based on responses to the eight items included in the Cannabis Use Disorder Identification Test-Revised (CUDIT-R), summed for a total score out of 32 points, with higher scores indicating increased symptoms of CUD.[31,32] Positive values of the change score outcome variable indicate an increase in CUDIT-R score at follow-up compared to baseline, suggesting a greater risk of CUD. This measure was designed to screen individuals for problematic cannabis use with items referencing frequency of cannabis use, ability to abstain from cannabis use, impacts of cannabis use on daily function, time spent obtaining/using cannabis, emergent issues with cognition, use of cannabis in circumstances where there is

potential physical harm, and thoughts of limiting cannabis use during the last 6 months.[31] The CUDIT-R's reliability, test-retest reliability and discriminative ability have been demonstrated.[31]

2.2.2.2 Exposure

Change in cannabis use since the onset of the COVID-19 pandemic was determined based on responses to the item, "Has your cannabis use changed since March 2020 with the onset of the COVID-19 pandemic? (Responses: Yes - I use more, Yes - I use less, No - I use the same amount).

2.2.2.3 Covariates

Covariates (collected at wave 1) included: age (continuous), gender (man or boy, woman or girl, or gender expansive), rurality (urban, suburban, or rural), and ethno-racial identity (Black, East/Southeast Asian, Indigenous, Latino, Middle Eastern, South Asian, White, and Other). Due to low sample sizes, the ethno-racial categories were collapsed into White, Non-White/Other (i.e., those who indicated one racial category other than White), and mixed ethno-racial group (respondents selected ≥2 ethno-racial groups). Subjective social status (SSS), a surrogate measure of the socioeconomic status of respondents, was ascertained by asking participants to place their family along a continuum (1-10) where 1 represents the most access to educational, employment and financial opportunities and 10 represents the least access to these opportunities based on the MacArthur Scale of SSS.[33,34] The scores were then categorized as: low SSS (8-10), middle SSS (4-7), and high SSS (1-3).[35] Mental distress was assessed using the Kessler Screening Scale for Psychological Distress (K6), a validated 6-item measure of

nonspecific psychological distress, which was summed to yield a total score out of 24, with higher values indicating greater levels of distress.[36]

2.2.3 Statistical Analyses

Descriptive statistics at baseline were generated to describe the analytic sample (n = 1,579). The differences in sample characteristics by the direction of change in cannabis use since the onset of the COVID-19 pandemic (increase, decrease, no change) and of the overall sample were described using cross-tabulations, chi-square tests for categorical covariates, and analysis of variance tests for continuous covariates.

The association between the change in cannabis use since the onset of the COVID-19 pandemic and the change in CUDIT-R score between survey waves was tested using multiple linear regression models adjusted for all covariates. Two-way interactions between change in cannabis use since COVID-19 and gender and age were tested to examine possible differential associations between the changes in cannabis use since COVID-19 and the outcome. Models were assessed for multicollinearity using the variance inflation factor (VIF), and likelihood ratio tests were employed to determine which covariates should be kept in the model. A complete case analysis strategy was implemented as there was <5% data missingness among the covariates and exposure variables.

A sensitivity analysis was conducted to assess the robustness of the findings from the complete case analysis, wherein multiple imputations were operationalized for instances of missing values. Values were imputed for all missing measures of interest, as outlined in Section 2.2, for participants who responded to both survey waves (n = 2,262), and an adjusted linear regression was performed. All analyses were conducted using SAS Software Version 9.4®.[37]

2.3 Ethics Approval

Informed consent was obtained from all participants included in the cannabis cohort study. Research ethics committee review and approval were obtained from the Research Ethics Board (REB) at the Centre for Addiction and Mental Health (2021/001) and the University of Ottawa (H-07-24-10535).

2.4 Results

2.4.1 Participants

The overall characteristics are presented in **Appendix D.** Of the 1579 youth included in the study, the majority identified as women or girls (55%) (33% man or boy and 12% gender expansive/other), White (66%) with a mean age of 22 years at baseline (Standard Deviation [SD]=3.21) **(Appendix D)**. About two-thirds (65%) of our sample reported residing in urban areas (25% suburban areas and 10% rural), and the majority had an average SSS (68%). The mean total score on the K6 measure of psychological distress for the sample was 10.3 (SD = 4.87), and the mean baseline CUDIT-R score was 11.3 (SD = 6.05) (**Appendix D**).

2.4.2 Trends in Cannabis Use during the COVID-19 Pandemic

The characteristics stratified by change in cannabis use since COVID-19 are reported in **Table 1**. We found that 58% (n=918) of the sample reported increasing their cannabis use since March 2020, while 31% did not change, and 11% decreased their use during this period (**Table 1**). Of those who increased their cannabis use during the COVID-19 pandemic, the majority identified as women/girls (62%), White (72%) and were of average SSS (61%) (**Table 1**). There were consistent trends in participant characteristics across the increase, no change, and decrease

groups, with the majority of participants in each group being women or girls, White, urban dwellers, and of average socioeconomic status (SSS). The average baseline CUDIT-R scores were 12.8 (SD: 6.23), 8.3 (SD: 4.59), and 9.5 (SD: 5.23) for the increase, decrease, and no change groups, respectively. The adjusted mean CUDIT-R change score was 0.68 (SE: 0.2), -1.1 (SE: 0.4), and -0.85 (SE: 0.3) for the increase, decrease, and no change groups, respectively (**Appendix E**).

2.4.3 Regression Results for Change in CUDIT-R Score

2.4.3.1 Main Effects Model

The mean change in CUDIT-R score between survey waves was 0.22 (SD: 4.78), 0.89 (SD: 4.07) and 1.03 (SD: 2.93) fewer points for the increase, no change and decrease in cannabis use since the onset of COVID-19 groups, respectively. In both the unadjusted and adjusted multivariable linear regression models, self-reported increased cannabis use in response to the COVID-19 pandemic was associated with higher CUDIT-R scores across survey waves compared to participants who did not change their level of consumption (Beta Coefficient [β]: 1.49; 95% Confidence Interval [95% CI]: 0.99, 2.00) **(Table 2)**. While gender was associated with increases in CUDIT-R scores in the unadjusted model, the association was no longer significant after adjusting for the other covariates. Conversely, one's total score on the K6 psychological distress scale was significantly associated with a slight decline in CUDIT-R score at the unadjusted level. However, this relationship was no longer significant in the adjusted model. Participants residing in suburban areas had significantly higher CUDIT-R change scores than those in urban areas. Participants identifying as mixed race had a 1.04-point (95% CI: 0.18, 1.66) rise in CUDIT-R score compared to their White counterparts.

2.4.3.2 Interaction Model

To examine whether the association between changes in cannabis use during the pandemic (no change serving as the reference group) and changes in CUDIT-R scores varied by gender or age, we estimated a linear regression model that included a first-order interaction term for gender and age **(Table 2)**. The interaction between the change in cannabis consumption and gender was not significant, indicating a similar association with the outcome for each gender identity. There was a significant interaction between change in cannabis consumption and age in the increase compared to the no change group, wherein the CUDIT-R change score decreased by 0.15 points (95% CI: -0.30, -0.01) for each additional year in age between Waves 1 and 2. This finding suggests that the effect of increasing cannabis use during the pandemic on symptoms of CUD varied by the age of the participant when adjusted for covariates from the main effects model **(Figure 1)**. The results of the multiple imputation model (n = 2,262) remained consistent with the main findings from the complete case analysis **(Appendix F)**.

2.5 Discussion

This study examined the change in symptoms of CUD several years after the start of the COVID-19 pandemic in a sample of Ontario youth who use cannabis. Findings indicated that 58% of participants reported increasing their cannabis consumption since the onset of pandemic restrictions in March 2020. Research examining cannabis consumption during the pandemic has yielded mixed results; however, a majority of studies identified an increase in cannabis consumption during COVID-19 among 22-50% of their sample.[17,20–22,27,38,39] Repeated cross-sectional data of Canadians from the early waves of the pandemic in 2020 found that approximately half of respondents increased their cannabis use from pre-pandemic levels, and

there were higher odds of increase among those 18-29 years of age (Odds Ratio [OR]: 2.61, CI: 1.32, 517).[23] Longitudinal data on Canadian adolescent cannabis use identified an upward trend in consumption after the initial stay-at-home measures were lifted and remained increased throughout subsequent pandemic-related restrictions.[38]

Among those who reported increasing their cannabis consumption in response to the pandemic at baseline, there was a significant rise in CUDIT-R scores compared to those who did not change their usage. To further elaborate, if an individual reported increased cannabis use since March 2020 their change score would rise compared to the no-change group which aligns with and extends those of a longitudinal cohort study from the United States (n=67; mean age=35 years), which identified an increase in CUDIT-R score among participants over 6 months during the early wave of the pandemic in 2020.[40] This study did not focus on youth, nor incorporate regression analyses, nor differentiate amongst individuals who may have increased their usage during the pandemic, thus our findings complement this data by providing insight into the nuance regarding the impact of change in cannabis use during COVID-19 on CUDIT-R scores over an extended period with a larger sample size. This finding points to the sustained impact of pandemic-related stressors on young adults' substance use behaviours beyond the lifting of public health restrictions. Consequently, we observed a rise in behaviours associated with CUD, such as increased frequency of an inability to limit cannabis use or cannabis impairing one's ability to fulfill daily responsibilities, as measured by the CUDIT-R scale. These behaviours increase one's risk of experiencing cannabis-related harms regardless of whether an individual's score meets the threshold for CUD. Harms may include, but are not limited to, impaired cognitive function, anxiety, psychosis, depression, increased risk of cardiovascular events, and increased risk of school drop-out or unemployment.[8,9,41,42] The physical, mental and

psychosocial adverse effects of problematic cannabis use result in reductions in an individual's functional capacity, limiting their engagement with work or school and community, and many adverse health effects require medical intervention, stretching the limited healthcare resources in Ontario.[13] Substance use-attributable healthcare costs amounted to $122 million in Ontario in 2020, as per data from the Canadian Centre on Substance Use and Addiction and Canadian Institute for Substance Use Research.[43]

Furthermore, we observed a significant interaction between age and increased cannabis use compared to no change in cannabis use during the pandemic on the change in CUDIT-R scores. This illustrates differential effects of increasing one's cannabis usage depending on age, wherein younger participants exhibited less of a decline in CUDIT-R score based on the beta coefficient of the interaction term compared to older participants across survey waves. The sample consisted of individuals between the ages of 16 and 30 at baseline, which captures the critical transition from adolescence, a crucial period in neurodevelopment during which one is more susceptible to cannabis-related harms, to young adulthood.[44] The variability across ages may be due in part to age-related vulnerability to cannabis use. A longitudinal study based in the United Kingdom followed a sample of adolescents (16-17 years) and young adults (26-29 years) who use cannabis longitudinally, finding that adolescents scored on average 3.7 points higher on the CUDIT-R measure compared to young adults, even when accounting for quantity of cannabis consumption.[44] Similarly, a longitudinal study from Australia followed adolescents (14-15 years) for 21 years, reporting CUD diagnoses to peak at age 20, suggesting lesser effects of changing cannabis use patterns in young adulthood.[7] Pandemic restrictions in Canada may have had differential impacts across this age group; individuals aged 15 to 24 years had the most significant drop in respondents reporting excellent mental health during the pandemic compared

to other age groups.[45] Among younger individuals who increased their cannabis use, there is considerable variation in their symptoms of CUD. This difference is influenced by living situations, demographics, and health beliefs, which help explain the overall decrease in CUDIT-R scores for this group.

Coping with boredom and negative affect are primary drivers of cannabis use in young adults.[46] Pandemic-related stressors exacerbated boredom and negative affect among young people, which resulted in increased use of cannabis as a coping mechanism, which was associated with increases in cannabis-attributable harms.[47,48] Cannabis use among this sample may have initially increased as a means to cope with pandemic-related stressors; however, our findings indicate that the effects of these increases persist beyond COVID-19, as evidenced by the positive association with increases in cannabis symptoms of CUD several years after the COVID-19 pandemic started.[48]

2.5.1 Limitations

The generalizability of this study is limited by the convenience sampling method, which hinders a representative sample of the Ontario youth population that uses cannabis. Convenience sampling was used for this study as the target population of youth who currently use cannabis represents a 'hard-to-reach' group.[49] There was differential attrition between survey waves, with participants reporting higher CUDIT-R scores being more likely to drop out. This could bias estimates; however, this nuance biases toward the null hypothesis, as those lost to follow-up were more likely to increase use and meet the threshold for CUD, making it more difficult to find a significant association. Due to the sensitive nature of the survey content and documented stigmatization against individuals who use cannabis, differential attrition was expected among

those reporting high CUDIT-R scores at baseline.[50] Despite this fact, the exposure to increased consumption was statistically significant in our model of the change in CUDIT-R score. It remained significant when multiple imputations were operationalized to address missing data, so our findings are considered conservative.

The self-reported nature of the data introduces the potential for recall and social desirability bias.[51,52] Youth study participants were asked in the 2022 cycle of the self-administered questionnaire to indicate whether their cannabis use had changed since March 2020, and participants may provide erroneous responses due to an inability to recall the exact frequency and quantity of cannabis use before and following March 2020. The potential for recall bias must be considered when interpreting findings from the study, as they may represent an over- or underestimation of changes in cannabis use in the wake of COVID-19.[51] Furthermore, social desirability bias must be acknowledged when analyzing self-reported substance use due to the sensitive nature of the topic.[52] Thus, there is potential information bias in this study from self-reported responses, given the sensitive nature of cannabis use and the retrospective collection of changes in cannabis use patterns.

Additionally, the factors driving the observed patterns of cannabis use may include residual effects of recreational cannabis legalization in Canada and the expansion of the legal cannabis market. In the 4 years following legalization, there was notable maturation of the retail market, with the number of cannabis retailers per capita in Canada increasing by an average of 122.3% annually. [53] However, the increases in stores and per capita sales began to slow in October 2021.[53] To account for the influence of legalization, the wording of the questions regarding changes in cannabis use referred explicitly to changes since the onset of the COVID-19 pandemic. Due to the specific wording of the question regarding cannabis use since March

2020 and the stabilization of the retail market, we can attribute the findings largely to the COVID-19 pandemic measures, while recognizing that legalization and retail market maturation may have also contributed to cannabis usage during the pandemic.

As this is a secondary analysis, we are confined to the use of data collected by the survey. Factors influencing cannabis use patterns as identified in the literature, including peer social networks, self-esteem and level of parental/guardian monitoring, are not assessed in the cannabis cohort survey.[54,55] The survey provided respondents with several options for the questions about gender and racial background; however, due to low sample sizes, many categories needed to be collapsed, limiting our ability to conduct sensitivity analyses and detect changes in estimates between racial and gender identities. Additionally, the survey item capturing whether participants increased, decreased or did not change their cannabis consumption since March 2020 does not provide information on the magnitude of change in substance use. Cannabis-related harms are strongly associated with the quantity and frequency of cannabis consumption.[8,56] Although the magnitude of change is not explicitly collected with this instrument, there is a question included in the CUDIT-R items that asks respondents how many hours they are under the influence of cannabis daily, which acts as a surrogate marker of the amount consumed. Finally, we found that the adjusted mean change in CUDIT-R score among those who increased their use was a statistically significant positive value, 0.68 points. This does meet the typical threshold of a change of 3 points on the CUDIT-R score for clinically relevant changes in CUD symptomatology.[57] However, we were limited by a 1 year follow-up period during which it is more challenging to capture behavior changes as studies have indicated that among those aged 12-25 the incidence of CUD is highest four years following initiation or escalation of use, although individual level factors including exact quantity of use and age at

initiation may expedite this timeline.[58] Thus, these findings serve to identify that those who increased their use since March of 2020 are at risk of worsening symptoms of CUD beyond the pandemic. To inform public health messaging regarding changes in substance use, the specific magnitude of change in cannabis consumption is less important than the overall trend of the direction of change among Ontario youth, which can be better generalized to the target population.

2.5.2 Implications

The increase in cannabis use and prevalence of symptoms of CUD may stem from the maintained access to the substance throughout the pandemic and the normalization of recreational cannabis use. For example, one qualitative study of young adults who increased their cannabis use during the pandemic found that many did so to cope with their boredom or declining mental health, and participants reported no disruption in their access to cannabis.[59] The policy environment for accessing recreational cannabis in Ontario needs closer review, as the growing availability of high-potency dried cannabis and flavoured edibles appealing to young adults is linked to increased risk of CUD.[60,61] In most Canadian jurisdictions, recreational cannabis retailers were deemed an essential service throughout the pandemic's fluctuating restrictions, with an increase in delivery and curbside pick-up modalities of sales.[62] Additionally, the cannabis market in Ontario greatly expanded during the study period, and greater market saturation may have impacted cannabis use and CUDIT-R scores.[53] It is therefore difficult to disentangle pandemic-related impacts on cannabis use from market-related impacts, and there may well be interactive effects between both expansion and the pandemic. This notion, in addition to an increased prevalence of use and recreational cannabis legalization, has contributed

to a discourse of normalization of cannabis use among Canadians.[63] Mental health service providers have identified that many of their youth patients feel cannabis is less harmful than other substances, and there remains a paucity of educational information for youth regarding the harms of cannabis use.[63] Furthermore, less than half of Canadian mental health providers surveyed reported screening or assessing cannabis use in their youth patients.[63] These findings underscore the need for enhanced training for service providers and targeted public health education for young people. Training is needed for primary healthcare providers and mental health professionals to ensure an accurate understanding of the consequences of cannabis use and approaches to implement valid screening tools to identify youth at risk of CUD. Sharing the principles of a harm reduction approach is vital to ensuring patient-centered care when treating patients who use cannabis, including youth.[64] Public health messaging targeting youth is needed to share the risks of frequent cannabis use and promote awareness of the lower-risk cannabis use guidelines.[65]

2.6 Conclusion

Many youth increased their cannabis use since the COVID-19 pandemic in Ontario, Canada. This trend is associated with significantly higher scores of CUD symptoms longitudinally. Youth are particularly vulnerable to the adverse psychosocial, mental and physical impairments characteristic of CUD. As such, a prompt public health response in the form of educational campaigns is needed to promote safe consumption and reduce cannabis-related harms in this population. In times of immense stress, such as the COVID-19 pandemic, this trend toward may persist. Further research is needed to identify reasons for increasing

cannabis use that predict escalation of use to identify at-risk youth and intervene on the course toward CUD.

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Table 1. Distribution of participant characteristics stratified by change in cannabis use during the COVID-19 pandemic using chi-square and analysis of variance tests (n=1579).

Characteristic	**Increase (n=918)**	**Decrease (n=176)**	**No Change (n=485)**	**p-Value**
Gender, *n (%)*				<0.0001
Man or boy	194 (21.13)	102 (57.95)	225 (46.39)	
Woman or girl	570 (62.09)	68 (38.64)	238 (49.07)	
Gender expansive/other	154 (16.78)	6 (3.41)	22 (4.54)	
Age (years), *mean (SD)*	22.46 (±3.25)	22.28 (±2.72)	21.78 (±3.25)	0.0008
Race/racial background, *n (%)*				<0.0001
White	660 (71.90)	129 (73.30)	249 (51.34)	
Non-white (visible minority, indigenous, other)	168 (18.30)	32 (18.18)	203 (41.86)	
Mixed race (>=2 racial categories)	90 (9.80)	15 (8.52)	33 (6.80)	
Geographic area of residence, *n (%)*				<0.0001
Urban (city)	594 (64.71)	144 (81.82)	296 (61.03)	
Rural	75 (8.17)	14 (7.95)	66 (13.61)	
Suburban	249 (27.12)	18 (10.23)	123 (25.36)	
Subjective social status, *n (%)*				<0.0001
Least access to opportunities	71 (7.73)	10 (5.68)	30 (6.19)	
Average access to opportunities	560 (61.00)	136 (77.27)	374 (77.11)	
Most access to opportunities	287 (31.26)	30 (17.05)	81 (16.70)	
Baseline CUDIT-R Score, *mean (SD)*	12.84 (±6.23)	8.31 (±4.59)	9.50 (±5.23)	<0.0001
Total score on K6 psychological distress scale, *mean (SD)*	10.89 (±5.35)	9.63 (±3.28)	9.42 (±4.20)	<0.0001

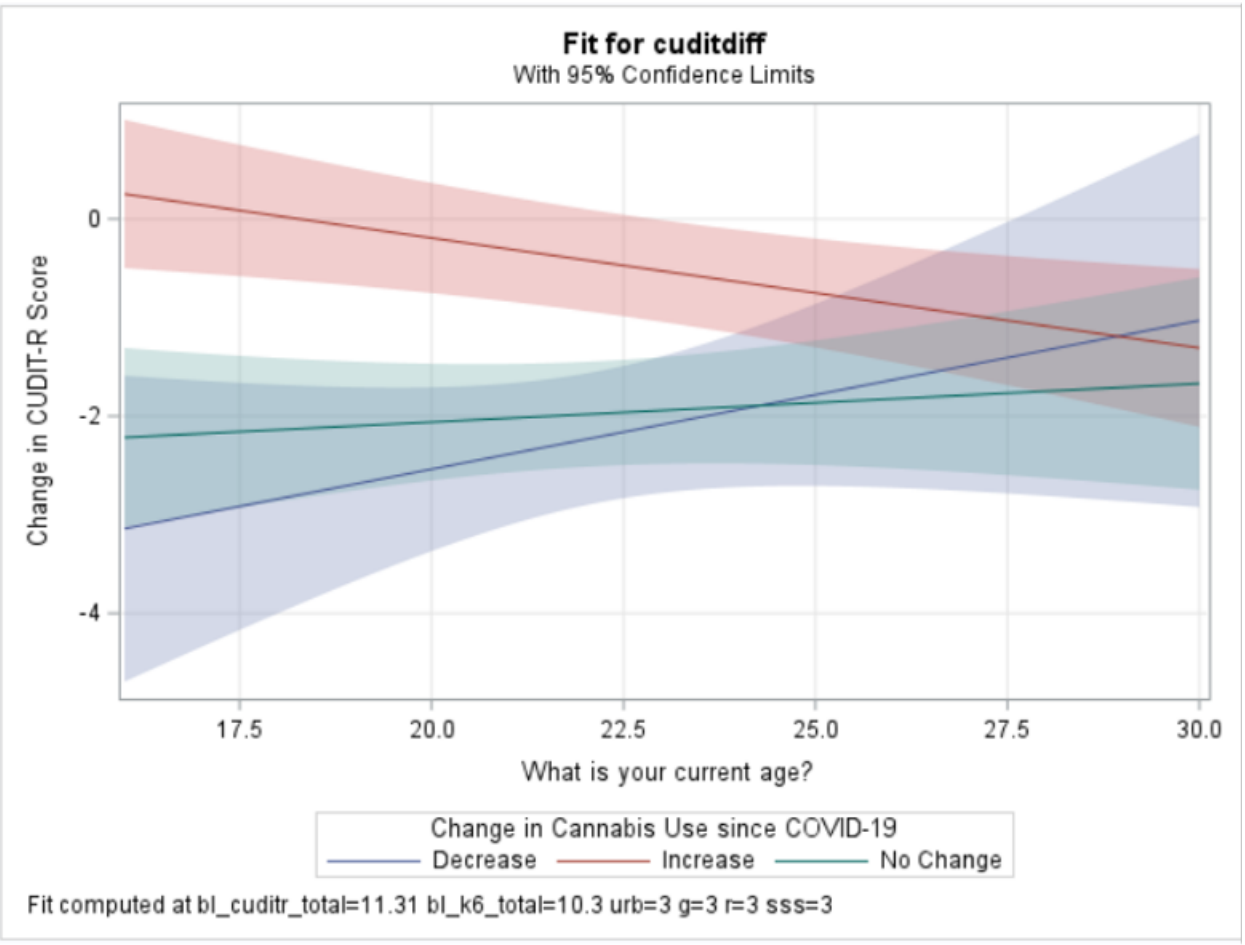
Abbreviations: SD, standard deviation; CUDIT-R, cannabis use disorder identification test – revised.

Table 2. Results of linear regression models examining the association between change in cannabis use during COVID-19 and symptoms of CUD, including the interaction effect of age on the association (n=1579).

Characteristic	**Model 1: Main Effects**		**Model 2: Interaction**
	Unadjusted β (95% CI)	**Adjusted β (95% CI)**	**Adjusted β (95% CI)**
Change in Cannabis Consumption (COVID-19)			
Increase	0.67 (0.19, 1.16)[a]	1.49 (0.99, 2.00)[a]	4.88 (1.60, 8.16)[a]
Decrease	-0.14 (-0.90, 0.62)	-0.20 (-0.93, 0.53)	-2.71 (-8.40, 2.96)
No change	Reference	Reference	Reference
Age x Change in Cannabis Consumption (Increase)	-	-	-0.15 (-0.30, -0.01)[a]
Age x Change in Cannabis Consumption (Decrease)	-	-	0.11 (-0.14, 0.37)
Age x Change in Cannabis Consumption (No Change)	-	-	Reference

Abbreviations: 95% CI, 95% confidence intervals; CUDIT-R, cannabis use disorder identification test – revised.
[a] p-value <0.05 denotes statistical significance.

Figure 1. Interaction plot between change in cannabis use and age in association with the change in CUDIT-R score across survey waves. Predicted values of CUDIT-R change scores, estimated from the linear regression model, are plotted against age. Separate lines represent each level of the change in cannabis use measure, illustrating how the association between age and CUDIT-R change score differs by level of change in cannabis use. Shaded areas indicate 95% confidence intervals.



3. Motivations for Youth Cannabis Use in Ontario during the COVID-19 Pandemic: A Longitudinal Cohort Study

Preface

Objective: To identify whether the motivating factors for increased cannabis use are associated with changes in symptoms of cannabis use disorder (CUD).

Author Contributions: Jessica Berryhill conducted quality assurances on the baseline and follow-up datasets, developed the analytical approach, performed all analyses, and wrote the draft manuscript. Dr. Tara Elton-Marshall provided methodological expertise on the analytic approach and the written manuscript. Dr. Ian Colman and Dr. Sameer Imtiaz revised the analytic approach, provided guidance on conducting the latent class and regression models, and reviewed the manuscript.

Publication: This manuscript is prepared for submission to the Drug and Alcohol Dependence journal.

Ethics: The University of Ottawa Research Ethics Board approved this secondary analysis (certificate, **Appendix A**).

Motivations for Youth Cannabis Use in Ontario during the COVID-19 Pandemic: A Longitudinal Cohort Study

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Abstract

Background: The COVID-19 pandemic and corresponding public health measures amplified stressors for many Canadian youth while disrupting their daily routines. Many individuals increased their cannabis use to cope with intense feelings of boredom, stress, and loneliness. However, there is a paucity of research exploring how motivations for using cannabis among youth during the pandemic relate to cannabis use, and in particular, problematic cannabis use after the pandemic.

Methods: This study used longitudinal data from youth (16-30) who use cannabis in Ontario and reported increasing their cannabis use since March 2020 (n=918). Latent class analysis was performed to identify subgroups based on the reasons participants selected as the factor(s) motivating increased cannabis use. Linear regression models examined the association between reasons for increased use and the change in score on the Cannabis Use Disorder Identification Test–Revised (CUDIT-R) between 2022 and 2023. Models were adjusted for socio-demographic characteristics.

Results: The latent class model exhibited poor class separation and was therefore not retained for further analysis. The linear regression models revealed that those who reported loneliness or boredom as the cause of their increased cannabis use had an increase in their CUDIT-R score, indicating worsening symptoms of cannabis use disorder (CUD) (Loneliness: $\beta=0.98$, $p<0.05$; Boredom: $\beta=0.84$, $p<0.05$).

Conclusion: Youth who use cannabis increased their cannabis use to cope with loneliness and boredom during the pandemic had worsening symptoms of CUD at follow-up. This study highlights the need for targeted public health interventions to address the factors driving youth problematic cannabis use.

(249/250 words)

Keywords: Cannabis Use; Cannabis Use Disorder; Reasons for Use; Youth; COVID-19; Boredom; Loneliness

Highlights

- Many youth reported increasing their cannabis use due to the pandemic
- Boredom, stress and loneliness were the most common reasons for increased use
- Participants reporting boredom and loneliness motives had higher CUDIT-R scores
- Findings suggest that symptoms of CUD are associated with the factors motivating use

3.1 Introduction

Recreational cannabis legalization came into effect across Canada in October 2018.[1] To date, evidence suggests that while there were some initial increases in cannabis use among youth immediately post-legalization, these changes in use stabilized in the years following legalization.[2–4] The 2024 Canadian Cannabis Survey (CCS) found that past-year cannabis use increased, although not significantly, from 2018 to 2024 among 16- to 19-year-olds (2018: 36%; 2024: 41%) and 20- to 24-year-olds (2018: 44%; 2024: 48%).[4]

Several conceptual models have illustrated the role of internal and external motives as key determinants in an individual's decision-making process for substance use. Cox et al. developed the Incentive Motivation Model of alcohol use, which posits that two dimensions can capture motivations for alcohol use: avoiding negative outcomes (negative reinforcement) and seeking positive outcomes (positive reinforcement).[5] This model consisted of 4 validated motivating factors: enhancement (internal, positive reinforcement), coping (internal, negative reinforcement), social (external, positive reinforcement), and conformity (external, negative reinforcement).[5,6] Simons et al.[7] then expanded this model to address cannabis use, adding a fifth motive, expansion, which encompasses the positive reinforcement and internal motive related to enhanced understanding of oneself, increased creativity, expanded knowledge, and increased awareness of personal experiences.[7] A systematic review of cannabis use motives among adolescents found that enhancement (defined as use to improve the quality of one's experiences), expansion (defined as use to alter one's perception), and social (defined as use to bond with others) were positively associated with cannabis use.[8] This review also identified coping (defined as a way to deal with negative affect), conformity (defined as a way because of peer influence), and boredom motives to be associated with increased cannabis use.[8] In a cross-sectional sample

of Canadian university students who use cannabis, those who endorsed enhancement and coping motives for use had significant positive correlations with increased Cannabis Use Disorder Identification Test – Revised (CUDIT-R) scores, indicating hazardous cannabis use.[9] The enhancement and coping motives were the primary predictors for male and female CUDIT-R scores, respectively.[9] Overall, the decision to initiate and maintain cannabis use is guided by positive and negative reinforcement motives valued by the individual.

Motivations for cannabis use influence the quantity and frequency of use, which in turn determines one's risk of cannabis-attributable harms.[10] Frequency and quantity, as well as the interactions of these measures, are significantly associated with a diagnosis of CUD and the presence of cannabis-related problems (CRP), specifically among youth and young adults.[10] CUD is critically important for public health because it is the most significant single contributor to the burden of cannabis use in Canada, particularly among those 15-24 years of age who have the greatest number of years of life lost due to disability attributable to CUD.[11] Youth are particularly vulnerable to cannabis-attributable harms such as intense anxiety, symptoms of psychosis, driving under the influence, decreased cognitive function, and substance abuse.[12] The increased vulnerability to cannabis-related harms is due to cannabis disrupting the development of the endocannabinoid system, which regulates neurotransmitters related to memory, mood, and motivation.[12] Youth cannabis use poses a significant risk to their physical and mental function, both in the short and long term.[13,14]

The COVID-19 pandemic and the consequent federal and provincial public health restrictions greatly influenced patterns of cannabis use in Canada. Restrictions fluctuated with variations in COVID-19 infection levels in each jurisdiction, following the implementation of lockdown orders that restricted social gatherings in schools, workplaces, and recreational

spaces.[15] This change in routine and ability to participate in recreational activities greatly affected the youth population with increased loneliness, mental health challenges, family conflict, health-related fears, and economic concerns.[16] With intensified experiences of stress, many youth increased their usage of cannabis as a means to cope.[17] Among Canadians aged 16-24 who used cannabis within the past year, 31% reported increasing their use due to the COVID-19 pandemic.[18] The literature points to a consistent trend of increased cannabis use among youth who already use cannabis.[19–22] Moreover, a repeated cross-sectional study including youth 10-24 years of age living in British Columbia examined self-reported symptoms of cannabis use problems between May 2018 and February 2022.[23] The study revealed there was a higher proportion of youth reporting regular cannabis use during the COVID-19 pandemic compared to pre-pandemic levels.[23] Thus, there is literature to support the hypothesis that, as a result of pandemic-related stressors, many youth increased their cannabis use, which likely contributed to more frequent reports of symptoms of CUD.

During the COVID-19 pandemic era, the reasons individuals used cannabis shifted due to the unprecedented nature of many of the stressors presented by pandemic-related restrictions in Canada. Newport et al.[19] conducted a systematic review examining the impact of COVID-19 on cannabis use, noting that self-isolation, anxiety, depression, lack of regular schedule, and continued availability of cannabis were the top reasons cited for increased cannabis use during this time. Struik et al.[24] conducted qualitative interviews with adults (33-34 years) who increased their cannabis use during the pandemic to explore how the pandemic affected their cannabis use behaviours. The most common reasons identified included coping with mental health challenges, boredom, and stress, in addition to cannabis being used as a form of self-expression.[24] Similarly, Hawke et al.[25] facilitated semi-structured interviews with youth who use cannabis, where they

described increasing their cannabis use to cope with isolation, boredom, and more free time. The exacerbation of many motives driving youth to increase their cannabis use, including boredom and coping with negative affect, likely contributed to increased cannabis use during the pandemic. One longitudinal study identified that Canadian young adults who adhered to social-isolation measures during the pandemic used 20% more cannabis than those not adhering to this measure, which suggests boredom, isolation, and coping as drivers of cannabis use.[26] Taken together, these findings underscore the importance of the reasons youth cite as the cause of their substance use behaviours and, in turn, their risk of experiencing cannabis-attributable harms.

3.1.1 Rationale

While several studies have focused on changes in cannabis use and motivating factors, there is limited evidence regarding how the shift in motivating factors for cannabis use due to pandemic-related restrictions relates to subsequent changes in symptoms of CUD. Therefore, the current study aims to examine how motivations for increased cannabis use are associated with symptoms of CUD. These findings can inform strategies to prevent increases in cannabis dependence in the youth population and tailor public health initiatives to those most at risk of experiencing adverse outcomes from cannabis use. Further, these findings can indicate whether there were sustained impacts of COVID-19 on symptoms of CUD after the COVID-19 pandemic.

3.2 Methods

3.2.1 Data Source

Data for this study are from the cannabis cohort survey, a longitudinal cohort study of youth aged 16 to 30 years who use cannabis in Ontario. Ethics approval for this study was obtained from the Centre for Addiction and Mental Health (CAMH), the University of Toronto, and the University of Ottawa. The survey was conducted using the Research Electronic Data Capture (REDCap) software.[27,28] The purpose of the study was to capture youth cannabis use habits, perceived risk of cannabis use, exposure to cannabis marketing, and awareness of existing public health initiatives to promote lower-risk cannabis use. Respondents were recruited through targeted ads on Instagram and Facebook, from an existing cohort study on vaping in Ontario at the University of Toronto, and via digital flyers distributed through CAMH's Cannabis Knowledge Exchange Hub and Evidence Exchange Network.

Wave 1 of this survey was conducted between January and August of 2022, and Wave 2 was conducted between January and August of 2023. Participants were deemed eligible for the study if, at baseline (Wave 1), they were between the ages of 16 and 30 years, resided in Ontario, and reported recent cannabis use, defined herein as use within the preceding 3 months. After screening and removing duplicate responses, participants with no data entered, incorrect responses to the attention check question, and those missing a unique identifier, there were 2,262 respondents at Wave 1 and 1,843 at Wave 2 (18.5% attrition). For the current analyses, only respondents who reported increasing their cannabis use since March 2020 were included in the analyses, as the study aims to explore the reasons for these increases in use (n=918). Of those eligible, there was ≤5% missingness for each variable of interest, and a complete case approach

was operationalized. **Appendix F** provides a comprehensive flow diagram illustrating the data preparation process.

3.2.2 Measures

3.2.2.1 Outcome

The change in symptoms of CUD between the baseline (Wave 1) and follow-up (Wave 2) survey was derived based on responses to the 8 items included in the Cannabis Use Disorder Identification Test-Revised (CUDIT-R), summed for a total score out of 32 points, with higher scores indicating an increase in symptoms of CUD.[29,30] Positive values of the change score outcome variable indicate an increase in CUDIT-R score at follow-up compared to baseline, suggesting a greater cannabis risk of CUD. This measure was designed to screen individuals for problematic cannabis use with items referencing frequency of cannabis use, ability to abstain from cannabis use, impacts of cannabis use on daily function, time spent obtaining/using cannabis, emergent issues with cognition, use of cannabis in circumstances where there is potential physical harm, and thoughts of limiting cannabis use during the last 6 months.[29] This measure has demonstrated excellent reliability with a Cronbach's alpha for internal consistency of 0.91, test-retest reliability of $r = 0.871$, and a strong discriminative ability as indicated by the area under the receiving operating characteristic (ROC) curve of 0.96.[29] The CUDIT-R showed high sensitivity (91%) and specificity (90%), indicating effective identification of CUD using this tool.[29]

3.2.2.2 Explanatory Variable

Reasons for increased cannabis use since the pandemic were derived from the following question in the baseline survey: "Why did your cannabis use change due to the COVID-19 pandemic? Select all that apply." Responses included: stress, anxiety, boredom, loneliness, lack of regular schedule, lost job due to COVID-19, more social gatherings (online or at home), access to cannabis (phrasing in survey "I have a lot of cannabis"), pain relief, other and no reason. Once a participant selected a reason, a value of 1 was recorded; otherwise, a value of 0 was assigned if the reason was left blank. Reasons "other" and "no reason" were excluded from analyses as they do not provide additional understanding of why there was an increase in cannabis use in this sample.

3.2.2.3 Covariates

Covariates included: age (continuous), gender (man or boy, woman or girl, or gender expansive), rurality (urban, suburban, or rural), and ethno-racial identity (Black, East/Southeast Asian, Indigenous, Latino, Middle Eastern, South Asian, White, and Other). Due to low sample sizes, the ethno-racial categories were collapsed into White, Non-White/Other (i.e., those who indicated one racial category other than White), and a mixed ethno-racial group (those who selected ≥2 ethno-racial groups). Subjective social status (SSS), a surrogate measure of socioeconomic status, was ascertained by asking participants to place their family along a continuum (1-10), where 1 represented most access to educational, employment and financial opportunities and 10 represented least access to these opportunities based on the MacArthur Scale of SSS.[31,32] The scores were then categorized based on existing literature into low SSS (8-10), middle SSS (4-7), and high SSS (1-3).[33] The Kessler Screening Scale for Psychological

Distress (K6) was used to measure nonspecific psychological distress, which was summed for a total score out of 24, with higher values indicating greater levels of distress.[34] Baseline CUDIT-R scores were added to the regression models to account for regression to the mean and baseline variability. This approach helps control for initial differences between participants at baseline, which may influence the magnitude of change observed over time. All covariates were collected from the baseline survey in 2022.

3.2.3 Statistical Analyses

Descriptive statistics were generated to examine the distribution of responses across each reason, as presented in Section 2.2.2, and all covariates for the analytic sample (n = 918). Chi-square tests were conducted for categorical covariates, and analysis of variance (ANOVA) tests were conducted for continuous covariates. During the exploratory data analysis, correlation was assessed between the nine reasons for increased cannabis use using Phi coefficients (φ), indicating collinearity. To address collinearity between the anxiety and stress variables (φ = 0.66), the anxiety variable was removed, as it demonstrated collinearity with other variables and is a concept that falls within the interpretation of the term stress. The Phi coefficient indicated collinearity between the boredom and lack of regular schedule variables (φ=0.37); therefore, the lack of schedule was removed from the analysis.

3.2.3.1 Latent Class Analysis

A latent class analysis was performed to identify subgroups of youth participants who increased their cannabis use since the onset of the COVID-19 pandemic in March 2020. The indicator variables inputted for the analyses were stress, boredom, loneliness, job loss, more

socialization, access to cannabis, and pain relief. Models were fitted for one-group to five-group latent class models, wherein parameter estimates were determined using the expectation-maximization and Newton-Raphson algorithms in RStudio (Version 2024.12.1+563).[35] Model fit was assessed using the Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC), and entropy.[36] Lower values of BIC and AIC indicate the optimal number of classes to achieve a parsimonious model.[36] Entropy values closer to 1 indicate adequate classification accuracy and class discrimination.[36] The interpretability of the classes in the best-fitting model was considered to ensure meaningful differences in classes that could then be used to explain differences in the reasons for increased cannabis use, as it relates to changes in CUDIT-R scores. Modal assignment would determine latent class membership, wherein each participant would be assigned to the most appropriate class based on posterior probabilities. If adequate class discrimination were achieved, a linear regression model including covariates from section 2.2.2 would be conducted to assess the differences in CUDIT-R change score across each class.

3.2.3.2 Linear Regression Models

Prior to regression modelling, continuous covariates were assessed for normality and linearity by visual inspection of a Q-Q plot. Linear regression models examined the association between the change in CUDIT-R score from the baseline to follow-up surveys and each reason for increased use. Each dichotomous variable representing a reason for increased cannabis use was added to the unadjusted and adjusted regression models to explore whether particular reasons were related to changes in the CUDIT-R score. In the adjusted models, we controlled for gender, age, ethno-racial background, rurality, subjective social status, baseline CUDIT-R score, and baseline K6 score. We adjusted for baseline CUDIT-R score to account for baseline

variability and focus on the direction and magnitude of change of the score. Covariates were added to the model following a stepwise approach. Multicollinearity in the regression models was assessed using the variance inflation factor (VIF) with a cutoff of 5, after which covariates may be combined or removed to ensure proper model fit. After fitting the final model, homoscedasticity was assessed by visual inspection of the residual plot. Regression analyses were conducted using SAS Software Version 9.4®, with a significance threshold of $p < 0.05$.[37]

3.3 Ethics Approval

Informed consent was obtained from all participants included in the cannabis cohort study. Research ethics committee review and approval were obtained from the Research Ethics Board (REB) at the Centre for Addiction and Mental Health (2021/001) and the University of Ottawa (H-07-24-10535).

3.4 Results

3.4.1 Participant Demographic Characteristics and Reasons for Increased Cannabis Use

Table 1 summarizes baseline participant characteristics for the analytic sample consisting of 918 youth who reported increasing their cannabis consumption due to the COVID-19 pandemic. The sample consisted of 62% women and girls (n = 570), 21% men and boys (n = 194), and 17% gender-diverse individuals (n = 154), with a mean age of 22.5 (±3.25) years. The majority of participants identified their ethno-racial identity as White (72%; n = 660), reported living in urban areas (65%; n = 594), and had an average subjective social status (61%; n = 560). At baseline, the average CUDIT-R score of participants was 12.84 (±6.23), and the average psychological distress scale score was 10.9 (±5.35), both of which fall just below the cutoffs of

≥13 points indicative of probable CUD from the CUDIT-R and severe psychological distress from the K6 scale. **Figure 1** displays the percentage of participants endorsing each reason for increasing their cannabis use during the COVID-19 pandemic. Participants were able to select more than one reason, if applicable. Boredom was the most commonly selected motivator for their change in cannabis consumption pattern, with 79.5% of participants endorsing this reason. The remaining reasons for increasing cannabis use during the pandemic were stress (65%), loneliness (43%), pain relief (24%), access to larger quantities of cannabis (16.4%), job loss due to COVID-19 (16%), and more opportunities for socialization (13%).

3.4.2 Latent Class Analysis of Reasons for Increased Use

Latent class analysis was performed to identify subgroups of youth participants based on the reasons they selected for increased cannabis use. **Table 2** summarizes the fit indices for each model, and **Appendix H** displays the indices graphically. The 4-class solution was selected as the best-fitting model among the five models, as it had the highest entropy value (0.61). **Figure 2** illustrates the conditional item response probabilities for reasons for increased cannabis use across latent classes. However, there was poor class separation, with similar item-response probabilities across classes, indicating overlap of reasons selected as the cause of increased cannabis use. Additionally, although the entropy was highest in the four-class model, it still indicated poor classification, as the posterior probabilities of an individual belonging to each class were similar, meaning that class membership for each participant was ambiguous. Thus, as the class separation was suboptimal, there was no further interpretation of the latent class analysis results.

3.4.3 Regression Analyses Examining Reasons for Increased Cannabis Use During the Pandemic and Changes in CUDIT-R Scores

The unadjusted and adjusted parameters for each linear regression model are displayed in **Table 3**. Selection of stress, pain, job loss, or more socialization as reasons for increased cannabis use was not significantly related to changes in CUDIT-R scores in the unadjusted or adjusted regression models. More access to cannabis due to higher quantities in an individual's possession was associated with decreases in the CUDIT-R score in the unadjusted model, but did not remain significant in the adjusted model. Boredom and loneliness, motives for increased cannabis use, were not significantly associated with CUDIT-R score in the unadjusted models, but they were significantly associated with an increase in CUDIT-R score between survey waves in the adjusted models.

3.5 Discussion

This study examined changes in symptoms of CUD among youth, several years after the onset of the COVID-19 pandemic, based on the self-reported motivations for increasing cannabis use. We examined the role of each of the following reasons as drivers of changed symptoms of CUD: boredom, stress, loneliness, pain relief, excess cannabis in their possession, job loss due to COVID-19, and more opportunities for using cannabis in social settings. Boredom (79.5%), stress (65%), and loneliness (43%) were the top-cited reasons youth in the sample reported increasing their cannabis use due to the COVID-19 pandemic. This aligns with the results of a repeated cross-sectional study of the evolution of young adult motives for substance use during the pandemic, wherein there was a significant increase over time in the frequency of boredom being a primary motive for cannabis use.[38] The leading reasons youth reported for increasing

their cannabis use are all classed as internal negative reinforcement motives based on the Incentive Motivation Model of cannabis use, meaning cannabis was used to cope with their feelings of boredom or loneliness, for example.[7] It is noted in the literature that internal cues prompting substance use have been associated with increased frequency of cannabis use, and negative reinforcement motives have been associated with a higher prevalence of cannabis-attributable harms.[8] Thus, participants reporting internal negative reinforcement motives for their increased cannabis use during the pandemic are potentially at higher risk of cannabis-attributable harms beyond the pandemic.

While the latent class model identified 4 subgroups of participants based on the reason(s) they selected for increasing their use, the model's discriminative ability was poor as indicated by overlapping response profiles across the classes. This suggests that the indicator variables, in this case, the reasons for increased consumption, lacked adequate variability and as such, there was no further interpretation of class structure. However, the literature review conducted before data analysis identified two articles that use latent class methodology to identify subgroups of individuals who use cannabis based on their reasons for use. An American study of young adults found that escape and coping motives for cannabis use were significantly associated with more frequent cannabis use even before the pandemic.[39] The majority of respondents selecting escape and coping motives for use reported using cannabis ≥40 times in the past year, the highest of any of the classes identified.[39] Although not explicitly exploring reasons for cannabis use during the pandemic, these results identify coping and avoidance motives driving increased cannabis use. These determinants extend to the pandemic period, as evidenced by the large proportion of participants in the current study selecting coping with boredom and stress as motivating their cannabis use during the pandemic. Thus, escape and coping motives likely describe a subgroup

of individuals who use cannabis and were likely to engage in problematic cannabis use during the COVID-19 pandemic, putting them at risk of cannabis-attributable harms.[40]

Those who reported loneliness and/or boredom as a reason for increased cannabis use during the COVID-19 pandemic had greater increases in their CUDIT-R change score, meaning they experienced a rise in symptoms of CUD, compared to those who did not select these reasons. This finding aligns with a scoping review detailing changes in cannabis usage due to the pandemic, wherein loneliness, boredom, stress, lack of schedule, and ease of access were cited as the primary drivers of increased cannabis use during the COVID-19 pandemic.[19,20,22,26] However, these studies did not extend their analyses to examine whether the increases in cannabis use based on the reasons for use were associated with changes in the likelihood of experiencing cannabis-related harms. Thus, examining the CUDIT-R score in the current study allowed us to examine whether changes in cannabis use due to boredom or loneliness impacted the frequency and severity of symptoms of CUD. This approach provides more valuable information to public health authorities as it extends findings of changes in usage patterns by capturing the clinical significance of these changes in cannabis use. Furthermore, loneliness and isolation motives for cannabis use were significantly associated with an increase in a composite measure of quantity by frequency of cannabis use.[26] Cannabis use to cope with mental health challenges, including stress, was identified as a leading reason for increased cannabis use among youth and young adults in numerous studies, as identified by a systematic review on the topic of changes in cannabis use in the youth population during the COVID-19 pandemic.[41] Overall, in our analyses and those in existing literature, coping motives specifically coping with boredom and loneliness were significantly associated with increased cannabis use and, in our analyses, with increased

symptoms of CUD, which can inform targeted interventions to equip at-risk youth to cope with negative affect more positively.

These motives may have been exacerbated during the pandemic, but loneliness, boredom, and stress have been identified as longstanding reasons for substance use.[8,42] Due to the continued influence of these motivating factors, public health interventions should focus on promoting safe usage of cannabis as outlined in the Lower-Risk Cannabis Use Guidelines (LRCUG) and recognizing that the likelihood of positive behaviour change depends on the intensity of the emotions influencing cannabis use.[43]

3.5.1 Limitations

The findings of this secondary analysis must be interpreted in light of the limitations, including reduced generalizability, the self-reported nature of survey items, and low variability in response patterns. Convenience sampling was used to gather the sample of youth who use cannabis, limiting the generalizability of findings to the broader Canadian youth population. Additionally, as the eligibility criteria for the source study required participants to have used cannabis in the preceding 3 months, the sample likely captured those who use cannabis more frequently. There is the potential for recall bias and social desirability bias impacting data accuracy, as all responses were self-reported.[44] In particular, questions regarding changes in cannabis use since the pandemic and the reasons motivating those changes relied on retrospective reports, which introduce the potential for differential recall and reduce data precision, potentially attenuating associations. Despite this fact, we were still able to find significant associations between particular reasons for increased use and the change in CUDIT-R score. Finally, there was low variability in response patterns to the binary variables representing a reason for increased

cannabis use during the COVID-19 pandemic and overlapping response options (i.e., boredom and lack of schedule), which resulted in poor discriminative ability in the latent class analysis.

3.6 Conclusion

Although reasons for increased cannabis use evolved during the COVID-19 pandemic, they continued to be primarily internal negative reinforcers of cannabis use, which can allow for targeted interventions to equip youth with coping strategies to lessen the impact the motivation has on their substance use patterns. There remains a concern for the health and well-being of youth who use cannabis, as there were increases in CUDIT-R scores based on the reasons they selected as the cause of their increased cannabis use since the onset of the pandemic in March 2020. Further studies are needed to examine how increased cannabis use during the pandemic and motivations for cannabis use relate to the severity of symptoms of CUD in the years after the pandemic subsided and there was a gradual return to normalcy. This will help identify if there are longer-term impacts of the pandemic on the trajectory of youth who use cannabis, experiencing the physical and psychosocial harms characteristic of CUD.

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Table 1. Participant characteristics for the analytic sample of those who increased their cannabis use due to the COVID-19 pandemic (n=918).

Characteristic	**Increase**
Gender, *n (%)*	
Man or boy	194 (21.13)
Woman or girl	570 (62.09)
Gender expansive/other	154 (16.78)
Age (years), *mean (SD)*	22.46 (±3.25)
Race/racial background, *n (%)*	
White	660 (71.90)
Non-white (visible minority, indigenous, other)	168 (18.30)
Mixed race (>=2 racial categories)	90 (9.80)
Geographic area of residence, *n (%)*	
Urban (city)	594 (64.71)
Rural	75 (8.17)
Suburban	249 (27.12)
Subjective social status, *n (%)*	
Least access to opportunities	71 (7.73)
Average access to opportunities	560 (61.00)
Most access to opportunities	287 (31.26)
Baseline CUDIT-R Score, *mean (SD)*	12.84 (±6.23)
Total score on K6 psychological distress scale, *mean (SD)*	10.89 (±5.35)

Figure 1. Percentage of participants endorsing each reason for increasing their cannabis use during the COVID-19 pandemic.

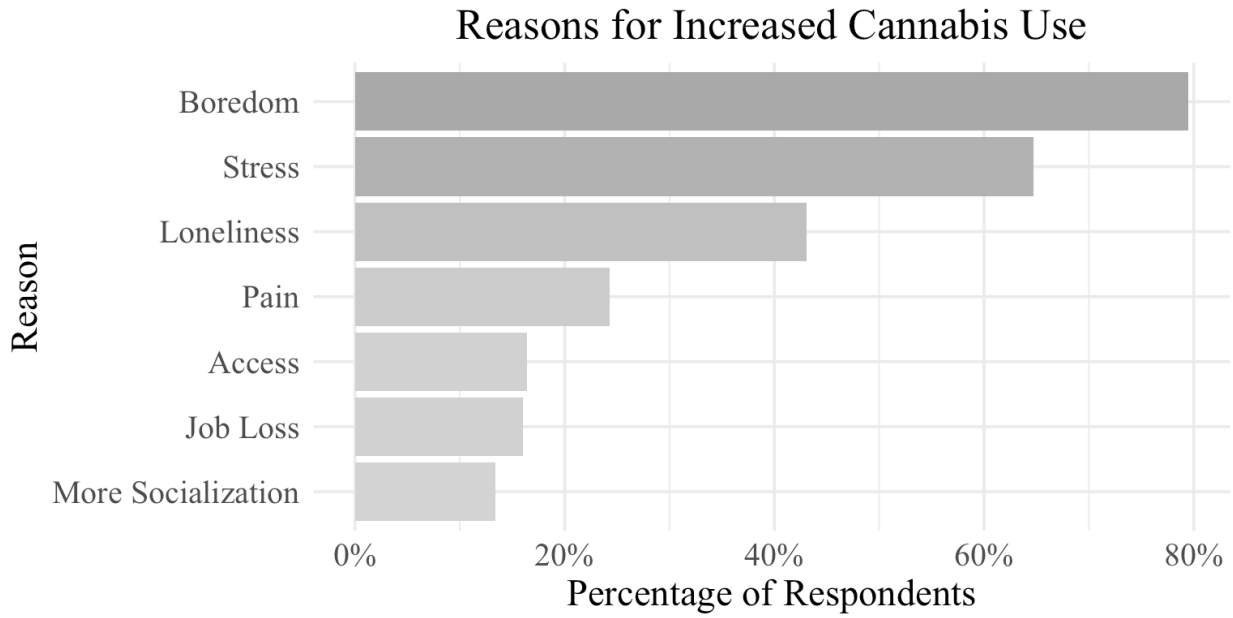

Table 2. Model fit indices (AIC, BIC, adjusted BIC, entropy) and classification probabilities for LCA models.

Number of Classes	**1**	**2**	**3**	**4**	**5**
AIC	6761.601	6552.814	6494.254	**6477.082**	6471.789
BIC	6795.356	6625.147	6605.164	**6626.57**	6659.855
Adjusted BIC	6955.678	6785.469	6765.486	**6786.891**	6820.176
Entropy	-	0.2072698	0.2785026	**0.6062452**	0.5619884
Average latent class probabilities	**-**	0.9115891	0.9004822	**0.748907**	0.7617264

Figure 2. Conditional Item Response Probabilities for Reasons for Increased Cannabis Use Across Latent Classes.

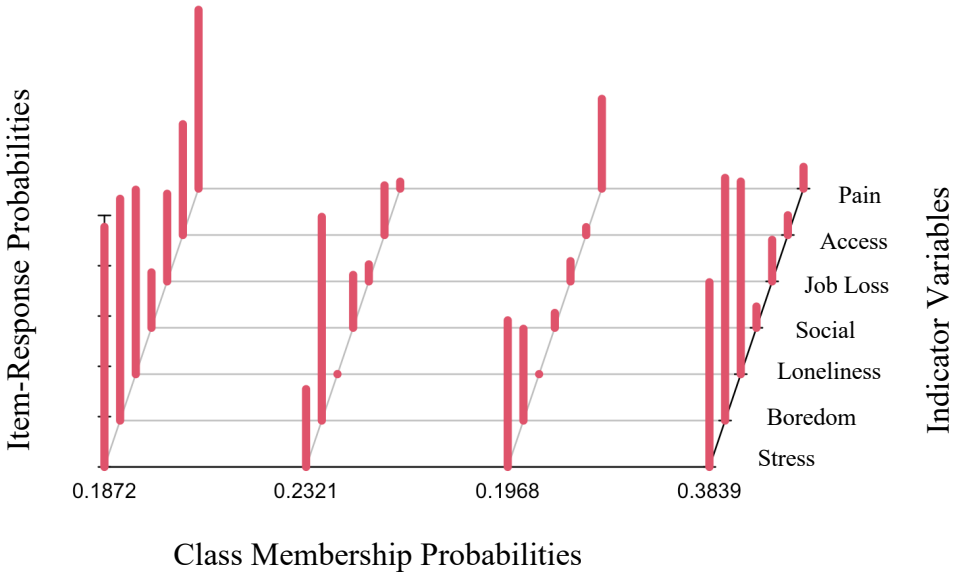

Table 3. Associations between self-reported reasons for increased cannabis use and changes in CUDIT-R score between the baseline and follow-up survey.

Reason for Increased Cannabis Use	Unadjusted β (95% CI)	Adjusted β (95% CI)[a]
Boredom	-0.09 (-0.86, 0.68)	0.84 (0.10, 1.56)[b]
Stress	-0.47 (-1.11, 0.18)	0.09 (-0.55, 0.72)
Loneliness	-0.52 (-1.15, 0.10)	0.98 (0.34, 1.61)[b]
Pain	-0.12 (-0.84, 0.60)	-0.16 (-0.85, 0.53)
More access	-0.87 (-1.71, -0.04)[b]	-0.20 (-0.99, 0.60)
Job loss	-0.73 (-1.57, 0.12)	-0.03 (-0.84, 0.78)
More socialization	-0.08 (-0.99, 0.83)	-0.34 (-1.19, 0.52)

[a] Model adjusted for gender, age, ethno-racial background, rurality, subjective social status, baseline CUDIT-R score, and baseline K6 score.
[b] p-value <0.05 denotes statistical significance.

4. General Discussion

This thesis aimed to examine whether changes in cannabis use during the COVID-19 pandemic led to a shift in the severity of symptoms of CUD in the youth population. To gain further insight into this relationship, we analyzed the associations between particular reasons for increased cannabis use during the pandemic and changes in cannabis dependence levels as the pandemic restrictions subsided. Overall, these findings advance our understanding of how the individual's responses to the COVID-19 pandemic influenced cannabis use in Ontario youth.

4.1 Summary of Findings

4.1.1 Changes in Youth Cannabis Use During COVID-19

We employed linear regression modelling of the differences in CUDIT-R scores, a measure of the severity of cannabis-related problems, as a function of changes in cannabis use due to the pandemic. Socio-demographic characteristics, as outlined in Section 2.2.2, were added as covariates to the model to control for potential confounding factors. Multiple imputation was utilized to reduce bias resulting from participants lost to follow-up, who had significantly higher CUDIT-R scores at baseline. The findings were consistent across both the complete-case model and the multiple-imputation model. Differential attrition during longitudinal studies of youth who use cannabis more frequently or exhibit more symptoms of CUD at baseline could impact the findings, biasing towards the null as discussed by Doggett et al.[1] and Jackson et al.[2] In the complete case model, the removal of those lost to follow-up could have led to attenuation of the effect size. Despite the bias toward a null effect, we found that those who increased their cannabis use due to the pandemic had increases in their CUDIT-R score at follow-up compared to those reporting no change in use. Furthermore, our analysis

revealed a significant interaction effect between change in cannabis use and age on the CUDIT-R change scores, wherein younger individuals in the increased use group had higher CUDIT-R scores at follow-up compared to older individuals in the increased use group.

4.1.2 Reasons for Increasing Cannabis Use During COVID-19

Initially, we conducted a latent class analysis to identify underlying subgroups based on the reasons selected for increasing their cannabis use during the pandemic. The binary indicator variables captured whether each of the following reasons impacted the individual's cannabis use: boredom, stress, loneliness, pain, a large quantity of cannabis in their possession, job loss due to COVID-19, and increased opportunity to use the substance socially. However, the analysis did not yield distinguishable classes, likely due to overlap in response patterns and the limited discriminative ability of the indicators. Linear regression analyses subsequently revealed that participants who selected loneliness or boredom had increases in their CUDIT-R score compared to those who did not endorse these motivating factors, while holding all other socio-demographic covariates constant. Thus, boredom and loneliness motives were both among the leading reasons for increased cannabis use and were associated with rises in CUDIT-R score between the baseline and follow-up surveys.

4.2 Integration of Findings

Taken together, the findings from both studies included in the thesis suggest that a majority (58%) of Ontario youth who use cannabis increased their cannabis use due to the COVID-19 pandemic and the CUDIT-R score rose between the baseline and follow-up assessment points among those who indicated that they increased their cannabis use following

the COVID-19 pandemic. Further, among those reporting increased cannabis use, loneliness and boredom motives were associated with rises in CUDIT-R score. Ultimately, both increased cannabis use and factors motivating said change were significantly related to increases in CUDIT-R change scores between baseline and follow-up one year later. Increases in CUDIT-R scores over time may reflect escalation in cannabis-related problems and developing or worsening CUD.

4.2.1 Changes in Prevalence of Cannabis Use During the Pandemic

Many studies examined how the prevalence of cannabis use has changed since the pandemic, with results remaining mixed in the literature.[3–10] One longitudinal study of Canadian young adults (ages 20-34 years) found the prevalence of cannabis use increased from 17.5% pre-pandemic to 23.1% during the pandemic.[6] Additionally, results from a survey of addiction medicine professionals representing countries from around the world indicated that 42% of participating countries noted an increase in cannabis use among the general population.[11] Conversely, Dumas et al.[7] found a decrease in the prevalence of youth cannabis use among female adolescents during the pandemic. There was a decrease in the prevalence of cannabis use among a convenience sample of individuals above the age of 16 years in the Netherlands.[9] Finally, several studies from Canada reported that the prevalence of cannabis use remained stable during the pandemic.[4,5,8–10] These studies provide insight into the change in the number of individuals engaging in cannabis use. However, they primarily use convenience samples with differing definitions of current cannabis use, including daily use, use in the past 30 days, or lifetime use, without measuring how these changes in patterns relate to the frequency and

severity of cannabis-related problems. These figures aim to capture whether there were changes in cannabis use frequency or quantity at the individual level during the pandemic.

4.2.2 Changes in Use Among Those Using Cannabis During the Pandemic

Among those who use cannabis, there is more substantial evidence to suggest an increase in cannabis use during the pandemic, both in Canada[3–8,12–14] and abroad [9–11,15,16]. A scoping review identified 44% and 46% of included studies reported increases in cannabis use among young adults and adults, respectively.[12] Dumas et al.[7] found a significant increase in the average number of substance-using days, from 0.94 (Standard Deviation [SD] = 3.28) to 1.10 (SD = 3.76), following the onset of the pandemic in Canada. Similarly, repeated cross-sectional survey data from Canadians during the early stages of the pandemic revealed that among those aged 18-29 years who use cannabis, 62.0% reported increasing their cannabis use within the last week.[4] A scoping review of Canadian studies of cannabis use during the pandemic found that across all studies, 27-50% of individuals who use cannabis noted an increase in their use due to the pandemic.[3] Globally, studies conducted in the United States and Europe (Netherlands, Germany, Switzerland, Austria) also found that a large proportion of those who reported using cannabis increased their cannabis use during the pandemic period.[9–11,15,16] A study by Benschop et al.[9] noted that 32.9% of those who use cannabis reported increasing their use, and there was a significant increase in the number of days participants used cannabis weekly. Many of the international studies in this area of research highlighted that the most significant increases in cannabis use occur among those who use cannabis regularly compared to occasionally.[9,11,15]

Notably, increases in cannabis use were most prominent among youth. A Canadian cross-sectional survey of those who use cannabis revealed that 40% of individuals aged 16-19 and 36%

of individuals aged 20-24 increased their use due to the pandemic.[17–19] Many of these were cross-sectional studies that do not capture measurable changes in cannabis use, but instead rely solely on self-reported changes and no measure of change in risk of CUD, which is a significant concern for those increasing their use. Aggregate changes in cannabis use prevalence and patterns of use may mask substantial heterogeneity, particularly among individuals who escalated their use and continue to face an elevated risk of CUD. There remains a paucity of research examining changes in symptoms of CUD during the pandemic.

4.2.3 Symptoms of CUD During the Pandemic

Data on the changing patterns of cannabis use during the pandemic do not capture the outcomes of said changes, which can culminate in symptoms of CUD that are of great public health concern. It is therefore crucial to capture how these changes in use have impacted the health and wellness of those who use cannabis through measures of CUD, including the CUDIT-R. We observed a 0.62-point increase in CUDIT-R scores among participants reporting increased cannabis use due to the pandemic, adjusting for socio-demographic covariates. Further, our study found that younger participants who increased their cannabis use during the pandemic were more likely to have an increase in their CUDIT-R score at follow-up. COVID-19-related increases in cannabis use were more prevalent among younger individuals. A longitudinal study of individuals who used cannabis in the preceding 6 months in the United States found that there were significant differences in CUDIT-R change scores from pre- to post-onset of the pandemic between those under 29 years, those 30-45 years, and those above 46 years.[20] Despite the use of the CUDIT-R measure, this study solely analyzed differences in change scores between age groups and was not based on changes in frequency or quantity of cannabis use. Understanding

the relationship between changes in cannabis use due to the pandemic and subsequent changes in measures of symptoms of CUD is critical to identifying those at risk of CUD who require public health intervention. To the author's knowledge, there is no Canadian study that explored the relationship between changes in cannabis use due to the pandemic and changes in score on a validated measure of symptoms of CUD in the youth population.

4.2.4 Cannabis-Related Harms Among Youth

Young people under 25 years are more likely to face adverse effects from cannabis use because the drug can alter the functioning of the endocannabinoid system.[21] This system plays a crucial role in managing the brain's reward and stress responses.[21] The association between regular cannabis use in youth and psychiatric conditions, including psychosis and depression, as well as impaired cognition, have been well established in the literature.[21,22] Ultimately, there is a consensus in the literature that youth are at a higher risk for increased cannabis consumption, and our findings suggest that there are lasting impacts from increased cannabis use during the pandemic.[3–6,23–25] It is critical to not only consider the change in cannabis use due to the pandemic but also the association of said changes with cannabis-related problems, specifically symptoms of CUD such as continued use despite psychological or physical harms, neglecting personal responsibilities due to use, and tolerance-induced increases in use, which are highly prevalent in youth populations.[21,26] Based on the results of a systematic review among the general population who use cannabis, there is a 1 in 5 lifetime risk of developing CUD, with youth having the highest prevalence of CUD compared to other age groups.[27,28] Thus, our findings, in conjunction with the existing literature, support the need to target this population when implementing public health interventions aimed at reducing the onset and severity of CUD.

4.2.5 Reasons Motivating Increases in Cannabis Use During the Pandemic

The reasons youth report for increasing their cannabis use provide critical insight to explain usage patterns. Our study highlighted that loneliness and boredom were motives for use since the onset of the pandemic and were associated with increases in the CUDIT-R score. A nationally representative Canadian survey identified stress (65%), boredom (58%) and loneliness (39%) as the most commonly reported reasons for increased cannabis use during the COVID-19 pandemic.[23] These reasons, according to the Incentive Motivation Model of Cannabis Use, are internal negative reinforcement motives classified more broadly as coping motives.[29–31] It must be noted that while these motivations for increased cannabis use were present before the COVID-19 era, the pandemic amplified their prevalence, particularly among youth who use cannabis.[32] Data drawn from Canadians during the pandemic revealed a significant positive association between coping motives for cannabis use and increased frequency of cannabis use ($r=0.494$) as well as increased past-month cannabis use problems ($r=0.478$).[33] The use of cannabis to cope with negative affect, including loneliness and boredom, has been significantly associated with having a DSM-5 diagnosis of CUD (OR: 1.85, $p<0.01$).[34] Collectively, this evidence indicates that coping motives during the pandemic have increased in prevalence and increased one's likelihood of experiencing worsening symptoms of CUD. Identifying motives driving youth cannabis use may provide public health educators and service providers with a more comprehensive risk profile for CUD in youth populations who may continue to experience these emotions beyond the pandemic.

4.2.6 Changes in the Policy Environment

This research took place in the broader context of cannabis legalization in Canada, wherein there was market saturation of cannabis retailers, increased potency of available products, and continued discourse surrounding the norms and social acceptability of cannabis use. These factors likely played a role in one's decision to increase their substance use. Availability and accessibility to cannabis use have changed substantially since legalization, with an annual increase of 122.3% in stores per capita and 3305 cannabis retailers across Canada as of 2022.[35] There have been notable increases in the potency of the delta-9-tetrahydrocannabinol (THC) in cannabis products which is its principle addictive component, with dried cannabis having an average 3% THC content in 1980 and an average of 15% today, with some strains having a potency up to 30%, which increases the risk of CUD.[36] It is also critical to acknowledge that youth may be more likely to increase their cannabis use patterns due to the ongoing discourse surrounding the normalization and social acceptability of cannabis use. Several youth participants in Canadian qualitative studies have highlighted that they are seeing cannabis being used more frequently in high schools, and peers have a reduced perception of risks from use, particularly in the wake of recreational cannabis legalization in Canada.[37] Accordingly, another study found that only 16.4% of a youth sample in Canada regarded addiction to be one of the five most prominent health concerns from cannabis use, highlighting a lack of risk awareness in this population.[38] Furthermore, many mental health service providers have noted that many youth see cannabis as a 'natural' substance less harmful than some prescribed medications, including antidepressants.[39] Exposure to permissive social norms and peer influence within one's community can reinforce cannabis consumption among youth.[37] Thus, the attitudes and beliefs youth hold regarding the acceptability of cannabis use can shape their likelihood to initiate use,

increase use, and reach a level of probable CUD. All of these factors play into the likelihood of youth changing their cannabis use; however, it is not only legalization that contributed to changes in use. Global studies have identified increases in cannabis use during the pandemic in nations where recreational cannabis use has not been legalized.[11] Additionally, as discussed earlier, the primary reasons motivating youth to increase cannabis use are connected to pandemic-related effects and not necessarily to legalization. Ultimately, it is challenging to separate the specific impacts of the pandemic from the legalization effects, including greater market expansion. Moreover, pandemic impacts may have been amplified by the greater availability and expansion of the cannabis market.[35]

4.2.7 Trends in Alcohol Consumption During the Pandemic

The impacts of the COVID-19 pandemic on youth in Canada extend beyond cannabis use; pandemic-related restrictions also affected alcohol consumption. Existing studies estimate that 33.4% of Canadian youth who use alcohol increased their use due to the COVID-19 pandemic.[40] The mean number of days alcohol was consumed increased significantly among Canadian youth during the pandemic, and among those using alcohol daily, 72% reported increasing their use.[7,41] Consequences of increased alcohol use during this period are reflected in the 21.3% increase in outpatient visits for alcoholism or alcohol psychosis and a 6.2% increase in hospitalizations for causes entirely related to alcohol use in Ontario during the pandemic period.[42] The top cited reasons for increases in alcohol use during the pandemic were boredom (60%), stress (58%), convenience (53%), and loneliness (37%), which mirror many of the motives identified as drivers of increased cannabis use during the COVID-19 pandemic.[23] Thus,

pandemic-related increases in cannabis use and cannabis-related harms and a similar pattern was observed for alcohol use.

4.2.8 Addressing the Long-Term Public Health Burden of CUD

Overall, cannabis use poses a risk to the health of youth. Consequently, primary prevention of cannabis use in this population is key to preventing long-term health effects from use of the substance. Primary prevention is an efficacious approach to reducing the number of youth initiating cannabis use and delaying the onset of cannabis use. Based on findings from systematic reviews, the most effective cannabis use prevention modalities are school-based programs, online interventions, and culturally specific interventions. For instance, the effective Life Skills Training program delivered to elementary through to high school students by teachers or facilitators prepares students to use skills of resiliency, decision-making, stress and anxiety management, and social skills that aid in their ability to make informed decisions about substance use.[153] A meta-analysis identified prevention programs that combine education, social competence, and social influence, including cognitive and social skill development (e.g., assertiveness, self-esteem), to increase the ability of youth to refrain from substance use even in the face of media and peer influences encouraging substance use.[155] Thus, primary prevention programs for early onset cannabis use are a promising avenue to prevent cannabis-related harms among youth.

Additionally, these findings underscore the need to develop and implement public health initiatives that address the risks of cannabis use and CUD in the youth population, as there is potential for serious long-term physical, mental and psychosocial impairments. Early intervention is key to reducing these health impacts and providing youth with adequate support

to limit and prevent problematic cannabis use. The strongest empirical support is found for cognitive behavioural psychotherapies for youth with problematic cannabis use.[156] These interventions can consist of both individual and family-based therapies focusing on promoting youth engagement in their community, which is incongruent with substance use behaviours, providing strategies for reducing use, rewarding positive behaviours, and increasing motivation to limit cannabis use.[156] For instance, the combination therapy of motivational enhancement therapy and cognitive behavioural therapy (MET/CBT) assesses an individual's substance use patterns and employs motivational interviewing to increase their drive to limit their cannabis use.[156–158] MET/CBT encourages youth to discuss what is motivating their cannabis use and provides ongoing support for healthy behaviour changes using a harm reduction framework.[156] There was a significant reduction in past-month cannabis problems and substance use frequency among youth participating in MET/CBT compared to exemplary outpatient treatment programs, consisting of individual and family-based behavioural or cognitive therapies.[158] Evidence supports the feasibility of integrating community and school-based MET/CBT interventions. It demonstrates effectiveness in reducing the number of substance-using days among participants while also being cost-effective, as early intervention reduces healthcare utilization costs related to cannabis use.[159] Thus, MET/CBT is a feasible and effective intervention for youth who use cannabis that provides early intervention with cognitive and behavioural therapies to reduce the risks of CUD.

Efforts to address the long-term effects of cannabis use must go beyond individual-level programs to policy-level strategies to ensure a sustainable approach to reduce cannabis-attributable harms. Policies can enact structural changes in the environment that discourage cannabis use among youth. Regulations surrounding the marketing of cannabis and retail sale of

products appealing to the youth population should be refined and more regularly enforced, as evidence suggests youth continue to view advertisements that increase their intention to use cannabis in Canada.[160] Although not explored in the current study, there remains no regulation on the THC limit for dried cannabis products, which may need to be reconsidered given the harm of high-potency cannabis products. [4] It is therefore crucial that cannabis policy is evaluated to ensure it aligns with public health objectives of reducing early onset and frequent use of cannabis.

4.3 Strengths and Limitations

This study has several strengths. Firstly, the longitudinal design of the current study allows for the observation of individual changes in symptoms of CUD over time. Additionally, many general population studies of cannabis use do have sufficient sample sizes to examine cannabis use behaviours or trends across age or gender groups, as they include small samples of people who use cannabis, limiting statistical power to detect trends. However, respondents for the current study were youth who currently use cannabis, which ensures a sufficient sample size to examine the behaviours of those who use cannabis and any within-group variability, such as by age, which was detected in this study. Jurisdiction-specific data is crucial to explore youth cannabis use in the wake of the pandemic, as jurisdictions differentially implemented public health restrictions and the availability of legally sourced cannabis products during this time. Thus, by examining Ontario youth specifically, we were able to identify trends in use while understanding the unique context of the geographical region. The data collection instrument included items from the validated CUDIT-R measure of risk of CUD, enhancing the validity, reliability, and interpretability of the outcome. Similarly, the collection instrument asked those

who reported increasing their cannabis use due to the pandemic to identify reasons for said change from a pre-specified list that allowed us to comprehensively capture whether there was a change in use since the pandemic, why there were increases in use and how this was associated with changes in the CUDIT-R measure.

The results of this study should be interpreted in light of the limitations. Firstly, the sample was recruited using non-probabilistic convenience sampling, meaning the findings are not generalizable to all youth who use cannabis in Ontario; however, the study allowed for feasible and timely recruitment as well as an in-depth exploratory analysis of the trends of cannabis use in youth since the pandemic. Due in part to the sampling methodology, our sample overrepresented youth who were at risk of CUD at baseline, with 42.6% meeting the criteria on the CUDIT-R measure for possible CUD, which limited the ability to detect changes in the CUDIT-R cutoff category for each individual **(Appendix I).** Due to the limited sample sizes in key subgroups, such as gender-diverse individuals and those from minority ethno-racial backgrounds, we were unable to conduct subgroup analyses for some of these groups. Disparities in CUD diagnoses are more pronounced among individuals at the intersection of specific gender identities and ethno-racial backgrounds, and thus, targeted research is essential to understand better and address the needs of these populations.[61] Similarly, the age range of the sample captured individuals at various stages of neurodevelopment who occupy different social roles, including some who do not meet the minimum legal age for cannabis purchase in Ontario; however, we were underpowered to conduct sensitivity analyses involving age.

It is important to note that all the data was self-reported by the participants, which introduces the potential for recall bias as they were asked retrospectively whether their cannabis use changed since the onset of the pandemic in 2020. Additionally, we are unable to comment on

the trajectory of symptoms of CUD among participants, as it is unknown what occurred between March 2020 and the baseline assessment time point, and data collection only included two time points. The study did not include a measure of the quantity of cannabis use, which reflects instances of heavy episodic use, and is strongly associated with increased risk of CUD.[161] Investigators chose not to include questions regarding the quantity of cannabis used due to the scope and survey length, as well as challenges for participants to accurately report quantity, as it also differs by modes of use. Studies have shown that Canadian youth can more accurately report whether they increased the frequency of their cannabis use than changes in the quantity of use.[162] In a similar vein, the survey did not collect information on the potency of cannabis products used. There have been notable increases in the THC potency of cannabis products available at legal retailers, which could impact CUDIT-R scores as the increased potency is associated with increased risk of CUD.[147,163] It is complex to capture the quantity and potency of cannabis use that varies by mode of cannabis use. Still, in future, these measures could be collected to explore the level of impact this factor has on symptoms of CUD. In addition to recall bias, social desirability bias may have led to over- or underreporting of their cannabis use.[108]

Finally, this study uses a retrospective report to initially capture whether an individual indicated that they had changed their cannabis use since the pandemic in 2020, which is not long after the Cannabis Act was instituted in October 2018.[3] Cannabis legalization and the period immediately preceding legalization was associated with increases in the likelihood of cannabis use, daily cannabis use and cannabis-related problems among adolescents and adults in Ontario as of 2019.[111,114] The cannabis retail market rapidly expanded after the Cannabis Act was enacted, increasing the accessibility of cannabis products across Canada.[44] Thus, the change in cannabis use data items could be impacted by residual effects of recreational cannabis

legalization and retail market expansion in Canada. However, the survey question was framed and worded to capture changes in use specifically related to the pandemic, thereby increasing the likelihood that we are capturing impacts attributable to the pandemic effects. Increases in cannabis use during the pandemic were also noted in nations without legalization of recreational cannabis use, suggesting changes in cannabis use are not attributable to legalization alone.[135] We expected there would be increases in cannabis use frequency and symptoms of CUD over time in Ontario, and although the survey items aimed to capture changes in use related to the COVID-19 pandemic, legalization, including the expansion of the cannabis market could moderate this relationship.

4.4 Implications for Future Research

To build on these findings of sustained impact of increases in cannabis use related to the pandemic, future studies could conduct an additional wave of the cannabis cohort survey to evaluate whether increases in cannabis use and CUDIT-R score related to the pandemic are sustained in the longer term. In addition, employing a mixed-methods approach to the additional study wherein a subset of respondents participate in semi-structured interviews to gain further insight into their cannabis use patterns, lived experience using cannabis, and the factors motivating their continued use of the substance.[16] This information would provide a better understanding of the trend of youth cannabis use following the onset of the COVID-19 pandemic in March of 2020. Furthermore, it is critical to examine cannabis use trends in marginalized populations, as many are at higher risk of experiencing cannabis-related harms, including CUD. This information is vital to ensure equitable public health education initiatives and to provide evidence that informs responsible policy development, particularly as it relates to these

population groups. As detailed in the Lower-Risk Cannabis Use Guidelines (LRCUG), groups including pregnant individuals, racialized groups, and those with a diagnosed mental illness are at higher risk of experiencing health harms from cannabis use.[130] Thus, future research should focus on these marginalized groups to provide evidence to support public health responses to the adverse effects of cannabis use that minimize harm to these populations and actively consider them when designing education programs or drafting policy regarding warning labels on cannabis products or regulatory restrictions.

4.5 Conclusion

A longitudinal cohort study allowed us to examine trends in youth cannabis use since the onset of the COVID-19 pandemic in March of 2020. Our findings point to increases in symptoms of CUD over time when youth reported increasing their use due to the pandemic and cited loneliness and boredom as key motivating factors for using cannabis. Implementing addiction therapist-led MET/CBT in community and school-based therapy programs for youth cannabis use can encourage sustained reductions in cannabis use and cannabis-related problems. The intentional inclusion of marginalized populations in this domain of research remains critical to provide a complete picture of the state of cannabis use among Canada's youth to understand the trajectory from initiation of use to developing CUD.

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Thesis Appendices

Appendix A: Ethics certificate.

09/07/2024

Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

CERTIFICAT D'APPROBATION ÉTHIQUE | CERTIFICATE OF ETHICS APPROVAL

Numéro du dossier / Ethics File Number	H-07-24-10535
Titre du projet / Project Title	COVID-19 Pandemic Related Increases in Cannabis Use and Cannabis Use Disorder among Youth: A Longitudinal Study
Type de projet / Project Type	Thèse de maîtrise / Master's thesis
Statut du projet / Project Status	Approuvé / Approved
Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)	09/07/2024
Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)	08/07/2025

Équipe de recherche / Research Team

Chercheur / Researcher	Affiliation	Role
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09/07/2024

Université d'Ottawa

Bureau d'éthique et d'intégrité de la recherche

University of Ottawa

Office of Research Ethics and Integrity

Le Comité d'éthique de la recherche (CÉR) de l'Université d'Ottawa, opérant conformément à l'*Énoncé de politique des Trois conseils* (2014) et toutes autres lois et tous règlements applicables, a examiné et approuvé la demande d'éthique du projet de recherche ci-nommé.

L'approbation est valide pour la durée indiquée plus haut et est sujette aux conditions énumérées dans la section intitulée "Conditions Spéciales ou Commentaires". Le formulaire « Renouvellement ou Fermeture de Projet » doit être complété quatre semaines avant la date d'échéance indiquée ci-haut afin de demander un renouvellement de cette approbation éthique ou afin de fermer le dossier.

Toutes modifications apportées au projet doivent être approuvées par le CÉR avant leur mise en place, sauf si le participant doit être retiré en raison d'un danger immédiat ou s'il s'agit d'un changement ayant trait à des éléments administratifs ou logistiques du projet. Les chercheurs doivent aviser le CÉR dans les plus brefs délais de tout changement pouvant augmenter le niveau de risque aux participants ou pouvant affecter considérablement le déroulement du projet, rapporter tout évènement imprévu ou indésirable et soumettre toute nouvelle information pouvant nuire à la conduite du projet ou à la sécurité des participants.

The University of Ottawa Research Ethics Board, which operates in accordance with the *Tri-Council Policy Statement* (2014) and other applicable laws and regulations, has examined and approved the ethics application for the above-named research project.

Ethics approval is valid for the period indicated above and is subject to the conditions listed in the section entitled "Special Conditions or Comments". The "Renewal/Project Closure" form must be completedfour weeks before the above-referenced expiry date to request a renewal of this ethics approval or closure of the file.

Any changes made to the project must be approved by the REB before being implemented, except when necessary to remove participants from immediate endangerment or when the modification(s) only pertain to administrative or logistical components of the project. Investigators must also promptly alert the REB of any changes that increase the risk to participant(s), any changes that considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project or the safety of the participant(s).

Kim THOMPSON (GESTIONNAIRE / MANAGER)
Directeur / Director
Pour/For **Daniel LAGAREC** Président(e) du/ Chair of the **Comité d'éthique de la recherche en sciences de la santé et sciences / Health Sciences and Sciences Research Ethics Board**

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Appendix B: Survey items used to derive all variables analyzed in this study.

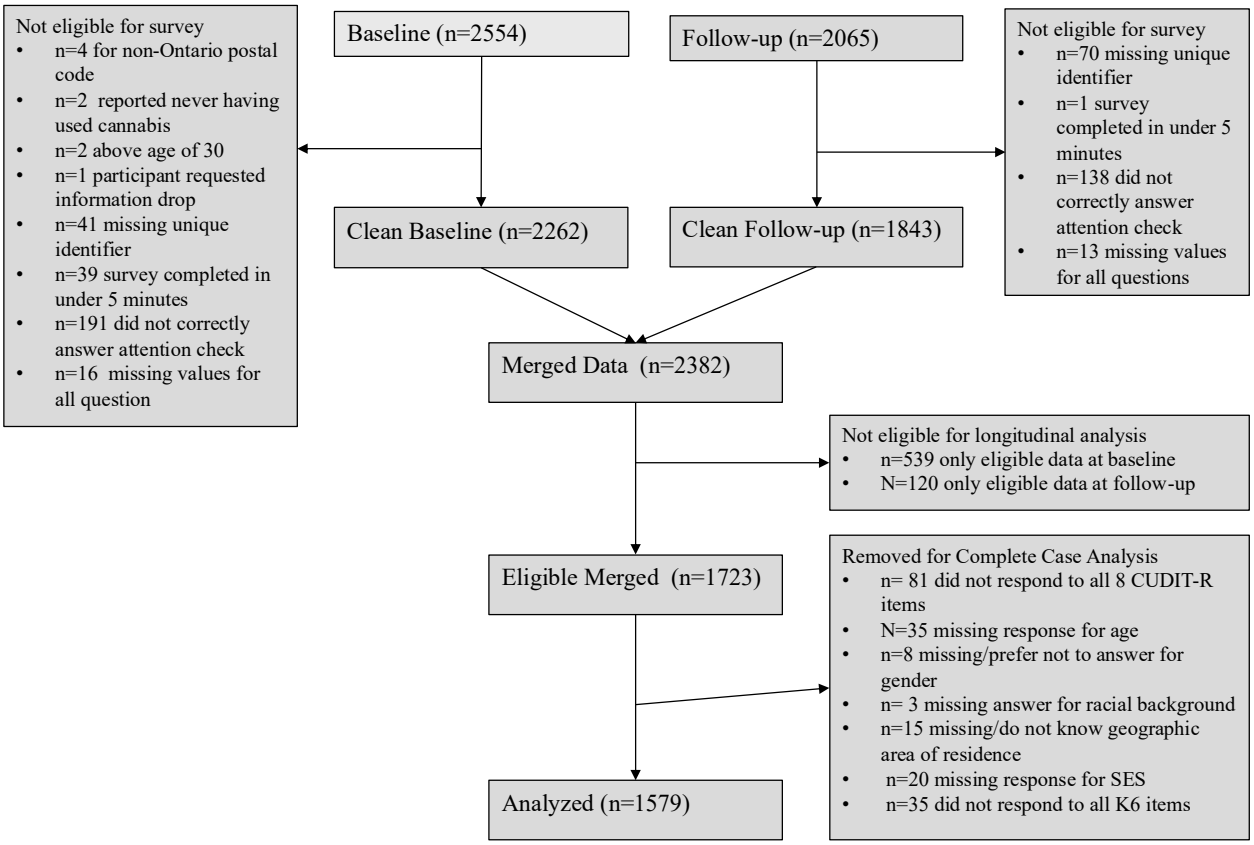
Variable	Survey Question	Response Options
Change in cannabis use	Has your cannabis use changed since March 2020 with the onset of the COVID-19 pandemic?	• Yes, I use more • Yes, I use less • No, I use the same amount
Total CUDIT-R score	How often do you use cannabis?	• Never • Monthly or less • 2-4 times a month • 2-3 times a week • 4 or more times a week
	How many hours were you "stoned" on a typical day when you had been using cannabis?	• Less than 1 • 1 or 2 • 3 or 4 • 5 or 6 • 7 or more
	How often during the past 6 months, if at all, did you find that you were not able to stop using cannabis once you had started?	• Never • Less than monthly • Monthly • Weekly • Daily or almost daily
	How often during the past 6 months, if at all, were you unable to meet what was normally expected from you because of using cannabis?	• Never • Less than monthly • Monthly • Weekly • Daily or almost daily
	How often during the past 6 months, if at all, have you devoted a great deal of your time to getting, using, or recovering from cannabis?	• Never • Less than monthly • Monthly • Weekly • Daily or almost daily
	How often during the past 6 months, if at all, have you had a problem with your memory or concentration after using cannabis?	• Never • Less than monthly • Monthly • Weekly • Daily or almost daily
	How often, if at all, do you use cannabis in situations that could be physically hazardous,	• Never • Less than monthly

	such as driving, operating machinery or caring for children?	• Monthly • Weekly • Daily or almost daily
	Have you ever thought about cutting down, or stopping, your use of cannabis?	• Never • Yes, but not in the past 6 months • Yes, during the past 6 months
Reasons for Use	Why did your cannabis use change due to the COVID-19 pandemic? Select all that apply.	• Stress • Anxiety • Boredom • Loneliness • Lack of regular schedule • Lost job due to COVID-19 • More social gatherings (online or at home) • I have a lot of cannabis • Pain relief • Other • No reason
Age	What is your current age?	Insert value
Gender identity	If you had to select ONE response that best describes your current gender identity for the purposes of a survey, what would it be?	• Man or boy • Woman or girl • Indigenous or other cultural gender identity (e.g., two-spirit, hijra, māhū) • Gender expansive (e.g., non-binary, genderqueer, agender) • Identity not listed • Prefer not to answer
Ethno-racial background	In our society, people are often described by their race or racial background. For example, some people are considered "White" or "Black" or "East/Southeast Asian," etc. While we know that race is not a scientific concept, it does often influence people's interactions with others and society as a whole. We ask these questions to better understand the role of race in people's experiences with cannabis. Which race category best describes you? Select all that apply.	• Black (African, Afro-Caribbean, African-Canadian descent) • East/Southeast Asian (Chinese, Korean, Japanese, Taiwanese descent, Filipino, Vietnamese, Cambodian, Thai, Indonesian, other Southeast Asian descent) • Indigenous (First Nations, Métis, Inuit descent) • Latino (Latin American, Hispanic descent)

		• Middle Eastern (Arab, Persian, West Asian descent, e.g. Afghan, Egyptian, Iranian, Lebanese, Turkish, Kurdish, etc.) • South Asian (South Asian descent, e.g. East Indian, Pakistani, Bangladeshi, Sri Lankan, Indo-Caribbean, etc.) • White (European descent) • Another race category
Rural-Urban status	Do you live in a rural or urban area?	• Urban (city) • Rural • Suburban • Don't know
Subjective social status	Imagine that Canadian society is set up as a ladder. People at the top of the ladder have had opportunities to get more education, income, and better jobs. People at the bottom of the ladder haven't had the same opportunities for education, income, and jobs. Now think of your family. Where would you place your family on this ladder	• 1 Least access to opportunities • 2 • 3 • 4 • 5 • 6 • 7 • 8 • 9 • 10 Most access to opportunities
K6 total score	During the past 30 days, how often did you feel nervous?	• All of the time • Most of the time • Some of the time • A little of the time • None of the time
	During the past 30 days, how often did you feel hopeless?	• All of the time • Most of the time • Some of the time • A little of the time • None of the time
	During the past 30 days, how often did you feel restless or fidgety?	• All of the time • Most of the time • Some of the time • A little of the time • None of the time

	During the past 30 days, how often did you feel so depressed that nothing could cheer you up?	• All of the time • Most of the time • Some of the time • A little of the time • None of the time
	During the past 30 days, how often did you feel that everything was an effort?	• All of the time • Most of the time • Some of the time • A little of the time • None of the time
	During the past 30 days, how often did you feel worthless?	• All of the time • Most of the time • Some of the time • A little of the time • None of the time

Appendix C. Flowchart of data cleaning and sample selection process. The diagram illustrates the steps taken to define the final analytic sample, including exclusions based on eligibility criteria and removal of participants with missing values. Sample sizes at each stage are shown, reflecting the progression from the initial dataset to the final sample used in the complete case analysis.



Appendix D: Characteristics of the overall sample (n=1579).

Characteristic	Total (n=1579)	%	p-Value
Change in Cannabis Consumption (COVID-19)			
Increase	918	58.14	
Decrease	176	11.15	
No change	485	30.72	
Gender, *n (%)*			<0.0001
Man or boy	521	33.00	
Woman or girl	876	55.48	
Gender expansive/other	182	11.53	
Age (years), *mean (SD)*	22.23 (±3.21)		
Race/racial background, *n (%)*			<0.0001
White	1038	65.74	
Non-white (visible minority, indigenous, other)	403	25.52	
Mixed race (>=2 racial categories)	138	8.74	
Geographic area of residence, *n (%)*			<0.0001
Urban (city)	1034	65.48	
Rural	155	9.82	
Suburban	390	24.70	
Subjective social status, *n (%)*			<0.0001
Least access to opportunities	111	7.03	
Average access to opportunities	1070	67.76	
Most access to opportunities	398	25.21	
Baseline CUDIT-R Score, *mean (SD)*	11.31 (±6.05)		
Total score on K6 psychological distress scale, *mean (SD)*	10.30 (±4.87)		

Abbreviations: 95% CI, 95% confidence interval; SD, standard deviation; CUDIT-R, cannabis use disorder identification test – revised.

Appendix E. Mean CUDIT-R score at baseline, follow-up, and change score by direction of change in cannabis use since the onset of the COVID-19 pandemic adjusted for sociodemographic covariates.

	Increase (n=918)	**Decrease (n=176)**	**No Change (n=485)**
Baseline[a], *Mean (SE)*	12.9 (0.3)	8.4 (0.5)	9.8 (0.4)
Follow-up[a], *Mean (SE)*	13.1 (0.3)	8.1 (0.5)	9.3 (0.4)
Change Score, *Mean (SE)*	0.68 (0.2)	-1.1 (0.4)	-0.85 (0.3)

Note: Separate linear regression models for baseline, follow-up, and change score.
Abbreviations: SE, standard error.
[a] Baseline CUDIT-R not included in model.

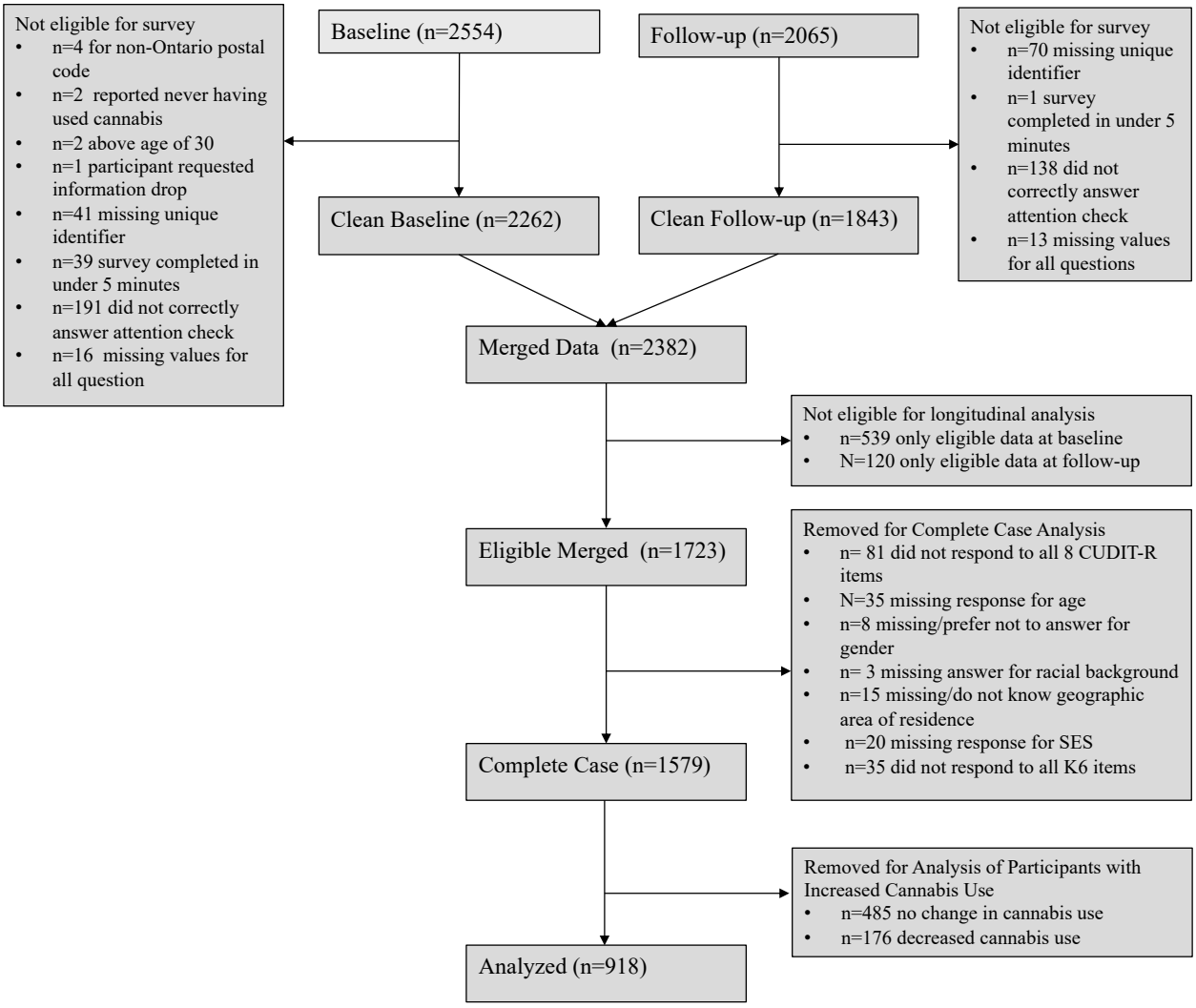
Appendix F. Results of multiple imputation linear regression models examining the association between change in cannabis use during COVID-19 and symptoms of CUD, including the interaction effect of age on the association (n=2,262).

Characteristic	**Model 1: Main Effects**		**Model 2: Interaction**
	Unadjusted β (95% CI)	**Adjusted β (95% CI)**	**Adjusted β (95% CI)**
Change in Cannabis Consumption (COVID-19)			
Increase	0.602 (0.11, 1.14)[a]	1.07 (0.57, 1.56)[a]	4.02 (1.09, 6.95)[a]
Decrease	-0.11 (-0.85, 0.63)	-0.14 (-0.88, 0.60)	-1.99 (-7.40, 3.42)
No change	Reference	Reference	Reference
Gender			
Man or boy	Reference	Reference	Reference
Woman or girl	0.58 (0.10, 1.05)[a]	0.47 (0.00, 0.94)[a]	0.44 (-0.03, 0.91)
Gender expansive/other	0.90 (0.18, 1.62)[a]	0.80 (0.10, 1.51)[a]	0.75 (0.04. 1.45)[a]
Age (years)	-0.004 (-0.07, 0.07)	-0.02 (-0.09, 0.05)	0.06 (-0.06, 0.17)
Race/racial background			
White	Reference	Reference	Reference
Non-white (visible minority, indigenous, other)	0.05 (-0.42, 0.52)	0.16 (-0.37, 0.68)	0.22 (-0.30, 0.75)
Mixed race (>=2 racial categories)	0.87 (0.10, 1.65)[a]	0.75 (0.06 1.43)[a]	0.75 (0.07, 1.44)[a]
Geographic Area of Residence			
Urban (city)	Reference	Reference	Reference
Rural	0.61 (0.25, 1.10)[a]	0.79 (0.30, 1.28)[a]	0.78 (0.29, 1.27)[a]
Suburban	0.33 (-0.35, 1.01)	0.46 (-0.25, 1.17)	0.50 (-0.22, 1.22)
Subjective Social Status			
Least access to opportunities	0.06 (-0.80, 0.92)	0.31 (-0.49, 1.11)	0.25 (-0.55, 1.06)
Average access to opportunities	Reference	Reference	Reference
Most access to opportunities	0.07 (-0.43, 0.57)	-0.002 (-0.55, 0.54)	-0.07 (-0.61, 0.48)
Baseline CUDIT-R Score	-0.22 (-0.26, -0.18)[a]	-0.24 (-0.28, -0.21)[a]	-0.25 (-0.28, -0.21)[a]
Total score on K6 psychological distress scale	-0.07 (-0.12, -0.03)[a]	-0.02 (-0.06, 0.02)	-0.02 (-0.07, 0.02)

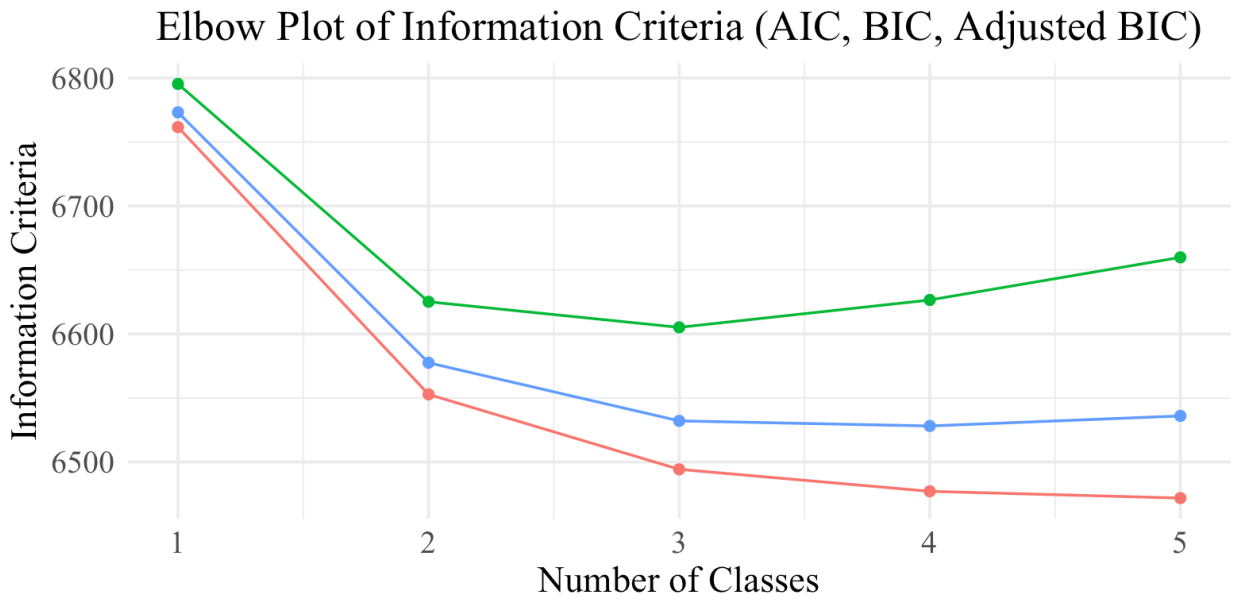
Age x Change in Cannabis Consumption (Increase)	-	-	-0.13 (-0.26, -0.003)[a]
Age x Change in Cannabis Consumption (Decrease)	-	-	0.08 (-0.16, 0.32)
Age x Change in Cannabis Consumption (No Change)	-	-	Reference

Abbreviations: 95% CI, 95% confidence interval; CUDIT-R, cannabis use disorder identification test – revised.
[a] p-value <0.05 denotes statistical significance

Appendix G: Participant flow chart for chapter 3 (n=918). The diagram illustrates the steps taken to define the final analytic sample, including exclusions based on eligibility criteria and removal of participants with missing values. Sample sizes at each stage are shown, reflecting the progression from the initial dataset to the final sample used in the analysis of individuals who increased their cannabis use due to the pandemic.



Appendix H: Elbow plot of fit indices for the latent class models.



Appendix I: Frequency and percent of participants (n=1,579) that fall into each category of change in CUDIT-R cutoffs from baseline to follow-up.

Direction of Change	**n (%)**
Low Risk at Both Waves	379 (24.0)
Low Risk at Baseline, Hazardous at Follow-up	71 (4.5)
Low Risk at Baseline, Possible CUD at Follow-up	36 (2.3)
Hazardous at Baseline, Low Risk at Follow-up	168 (10.6)
Hazardous Both Waves	147 (9.3)
Hazardous at Baseline, Possible CUD at Follow-up	105 (6.7)
Possible CUD at Baseline, Low Risk at Follow-up	49 (3.1)
Possible CUD at Baseline, Hazardous at Follow-up	130 (8.2)
Possible CUD Both Waves	494 (31.3)